DCV 700 DC Drives

Software Description

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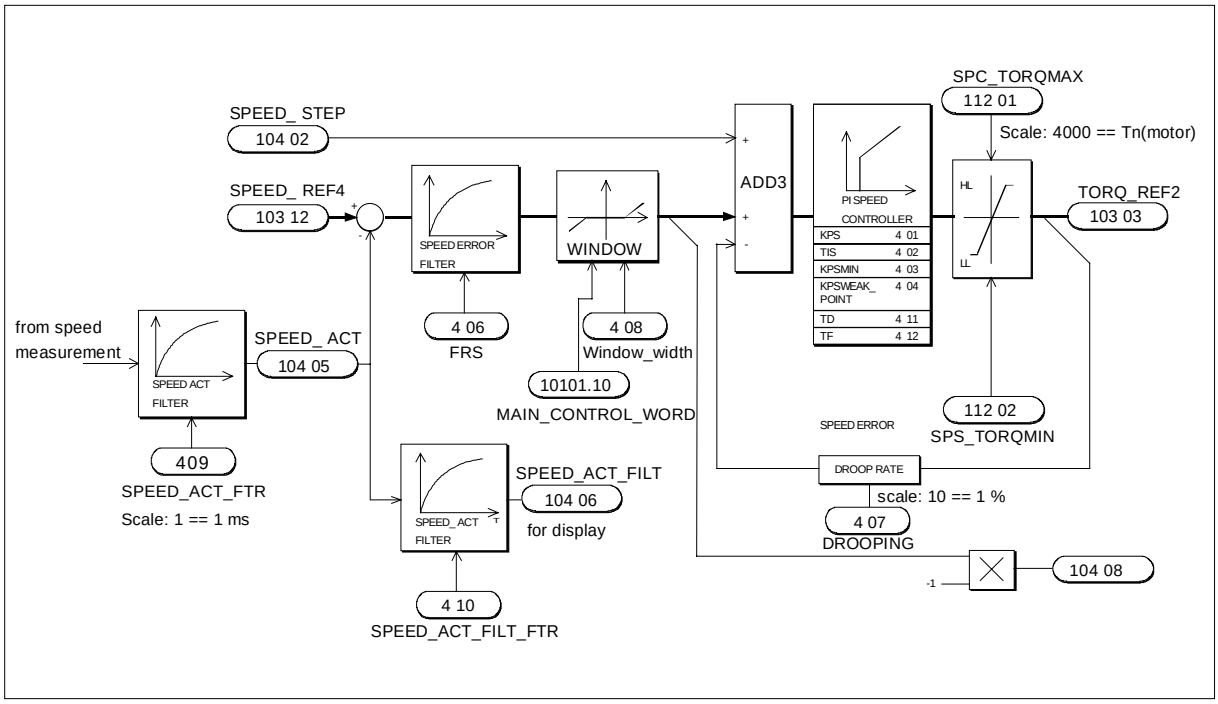

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Table of references:

For information on:	See:
Commissioning	DCV 700 Commissioning Manual
Hardware	DCV 700 Hardware Description
Installation	DCV 700 Installation Manual
Service	DCV 700 Service Manual

The technical data and specifications are valid at the time of printing.
We reserve the right to subsequent alterations.

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APPENDIX A: DCV 700 Control program
Parameter and signal list

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(code 37021717)

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1. GENERAL

The documentation of the DCV700 is divided into separate manuals in order to provide quick access to the required information . This manual

Software Description describes in detail the DCV 700 software and the utilization of field exciter units SDCS-FEX-1, SDCS-FEX-2 and DCF503/504.

Commissioning Manual covers instructions for commissioning from the incomer section to the drive section, and

Hardware Description introduces and describes all the external connections and settings of the DCV700 circuit boards. All these manuals of the DCV700 complements each other.

Installation Manual is for installing,

Service Manual is for fault tracing and maintanance.

1.1. Identification of the software revision

1.1.1. Identification of the converter software program revision

The **converter program** is stored in two FLASH-memory circuits **(D33, D34)** on the control board SCDS-CON-1. The labels of the memories identifies the revision of the software:

FLASH	**Software revision**
D33	**DC11.106**
D34	**DC11.106**

The number 11. is an identification number reserved for DCV700.
The 106 is a running number which will be increased always when the new program revision is released.

The program revision number can also be checked from The signal **CNT_SW_VERSION (123 01).**

Parameters are stored in one FLASH-memory circuit **(D35)** on the control board SCDS-CON-1.

1.1.2. Identification of the field exciter program revision

The software revisions of the field exciters can be checked from the signals

FEXC1_SW_VERSION (123-10).

FEXC2_SW_VERSION (123-11).

1.1.3. DRIVE-ID

The parameter **DRIVE-ID (23-01)** is freely definable by the user in order to mark the section number of the machine. The drive software does not use that parameter at all.

1.2. Handling of parameters and signals

Parameters are values that define the operation of the DCV700. Parameters can be modified by the APC application program or with a PC-based commisioning and maintenance tool, the **DDCTool**.
The DCV700 has **23 parameter groups** which are numbered from **1** to **23**. Parameters of a certain group belong to the same functional part of the program.

Signals are

reference values or commands from the APC or DDCTool
results from measurements or calculations done by the DCV 700 control program,

The drive tool can access the signals in the same way as parameters. The DCV700 has **23 signal groups** which are numbered from **101** to **123**. Signals of a certain group belong to the same functional part of the program as the parameters.

In this manual all references to the parameters and the signals are done by using brackets. **(12-34)** equals the group 12 , signal 34.

Detailed description of parameter and signal names as well as scaling factors are presented in document

DCV700 Control program
Parameter and Signal Description.

1.2.1. Scaling of parameters and signals

For controlling DCV700 and the motor, parameters and signals are scaled according to the function where the values are used for. The values are represented as internal units. Absolute values like amps are generated for display purposes but are not used for controlling purposes. Main scaling factors used in DCV700 software are explained briefly here .

SPEED	**20000** Maximum speed value. Selected by the parameter **SPEED_SCALING (13-18).** Used by the speed dependent functions like speed measurement, ramp, speed reference chain etc.
CONVERTER CURRENT	**4095** Nominal converter current. Correspond to signal **I_CONV_A (113-01)** Used by the converter protection functions like overcurrent limitation.
MOTOR CURRENT	**4095** Nominal motor current. Correspond to parameter **I_MOTN_A (13-02)** Used by the motor control.
FIELD CURRENT	**4095** Nominal field current. Correspond to parameter **I_MOT1_FIELDN_A (13-03)** Used by the motor control.
NETWORK VOLTAGE	**4095** Nominal network voltage. Correspond to parameter **U_SUPPLY (18-06)** Used by the motor control.
ARMATURE VOLTAGE	**4095** Nominal DC voltage. Correspond to parameter 1.35 * **U_SUPPLY (18-06)** Used by the motor control.
EMF VOLTAGE	**3786** Nominal EMF voltage. Correspond to parameter 1.35 * **U_SUPPLY (18-06)** Used by the motor control.
MOTOR FLUX	**4095** Nominal motor FLUX. Used by the motor control.
TIME	**0,001...1 sec** Time scalings depends on the functions.

1.3. Overview of DCV700 functions

The DCV700 flexibility allows the user to configure functions of the drive easily suitable for different applications.

Functions of the DCV700 are normally activated by selecting a certain value to the function activation parameter.

Here are briefly explained most important parts of the DCV700 software and their main properties.

Controlling the drive The DCV700 can be controlled either by **AP**plication **C**ontroller **APC** or by the **DDCTool** which is a PC-based commissioning and maintenance tool.

Drive logic is a part of the software which handles functions needed for controlling the drive like
- Local/Remote selection
- Start and stop sequences
- Fault handling
- Emergency stop etc.

Measurements For controlling the motor in a proper way the DCV700 measures
- Speed
- Converter current
- Field current
- Armature DC voltage
- Net AC voltage
- Heat sink temperature

There are also 5 DI-channels and 5 AI-channels that can be optionally used in various purposes e.g. measuring the motor temperature etc..

Speed reference The **Speed Ramp** is used to fine tune the motor speed. The APC can also define the slope of the ramp by the function called "**Variable Slope**". The output of the ramp can be **smoothen**ed if needed. The program can also calculate an additional torque reference needed during acceleration/deceleration using a function called "**Acceleration Compensation**".

Speed control The speed of the motor is controlled by the **PID**-control. The controller is designed so that it can easily be adjusted to the different environment in order to facilitate the commissioning work.

Torque reference

The APC can command the DCV700 also by using torque reference. In case of **Master/Follower** connection the master-drive can transfer its torque reference to the slave.

Current controller

The current of the motor is controlled by the PI-type controller. The controller can be tuned using an "Auto-Tuning" -facilities.

Field excitation

There are several different ways to control motor field depending on the application like:

- uncontrolled diode field exciter **SDCS-FEX-1**
- 1Q current controlled field exciter **SDCS-FEX-2** and **DCF503** enabling field weakening area.
- 2Q current controlled field exciter **DCF503** enabling field weakening area and field reversal.

Additionally it is also possible to use non-ABB field exciters. In that case acknowledge signals are read using DCV700 AI or DI -channels.

EMF-controller

When an accurate torque control is needed or the field weakening function is used, the EMF-control adjusts the field so that the armature voltage stays at a desired level.

Limitations

The user can select current limits for the armature controller. There is also a possibility to reduce the armature current limit proportionally to the speed. APC can independently limit also the speed controller output and the external torque reference if the application demands that.

Diagnostic

The DCV700 check the condition of the SCDS-CON-1 board every time when an auxiliary power is switched on. The board has also the Watch-Dog -function that supervises the condition during running. For the user there are:

- **Fault logger** that stores 100 latest fault and alarm events, the time for each events, a short text explanation and the numeric code.
- **Data logger** that has 6 channels, each 1000 samples long and the shortest sampling interval is 1 ms.

Communication

The DCV700 has 4 communication links

- TC-link for the APC
- DDCTool link for PC-tool
- Master/Follower link between drives
- FEX -link for SDCS-FEX-2, DCF503/504 units.

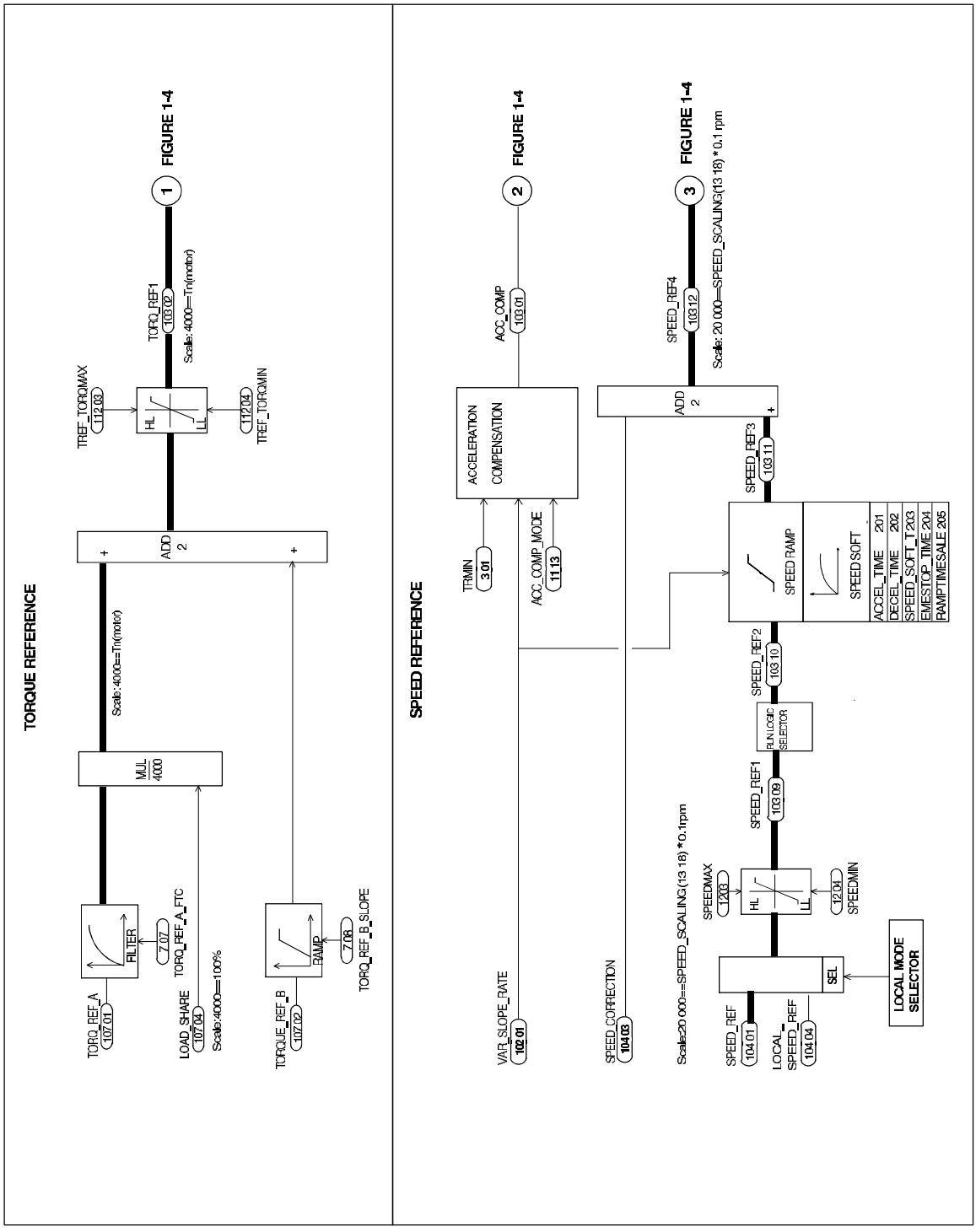


Figure 1 The speed and the torque references. Bold lines show the main line from given references to the firing unit.

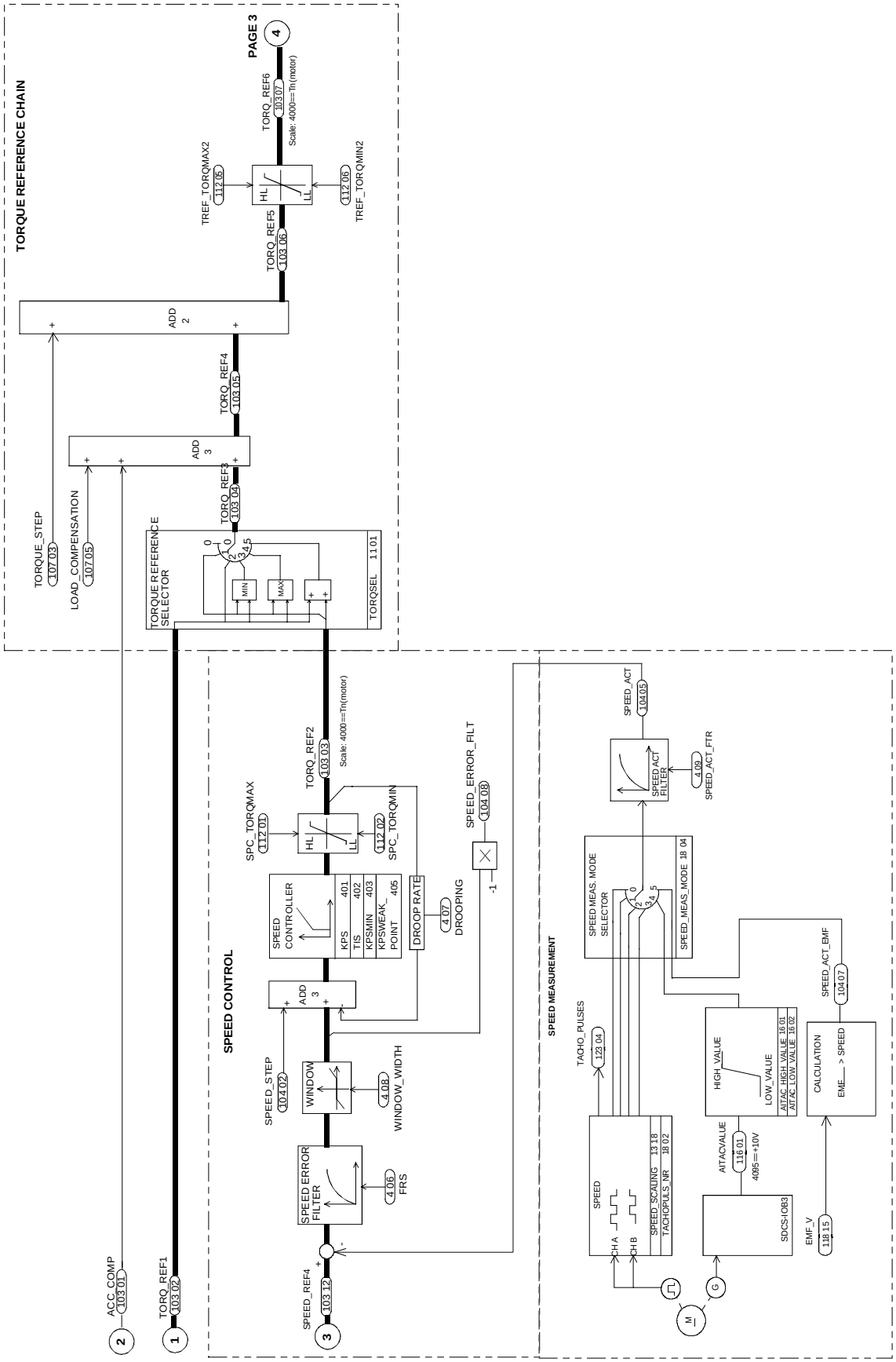


Figure 2 Speed measurement, speed controller and torque reference chain.

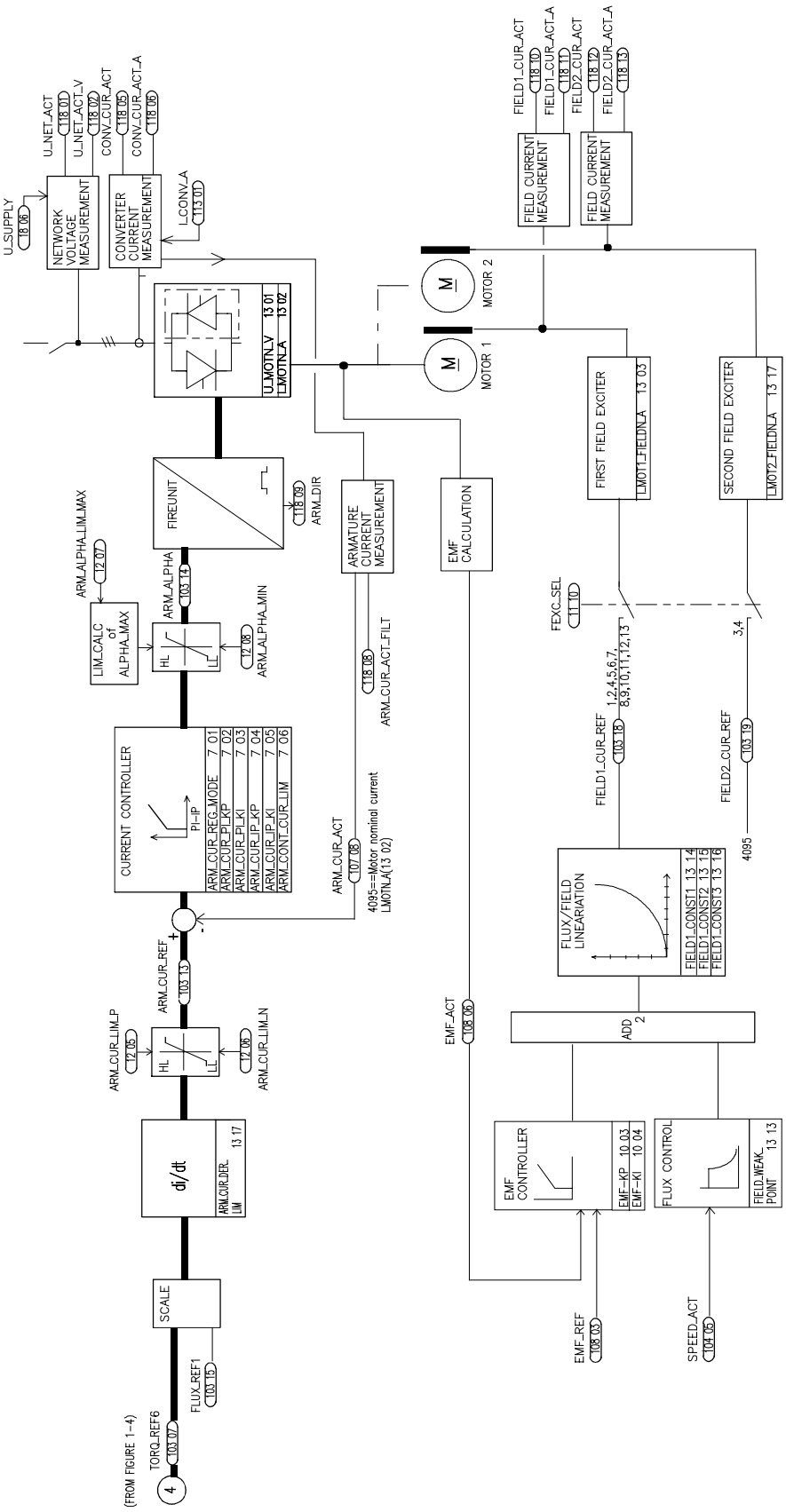


Figure 3 Armature current control, field excitation and current measurements.

2. LOGIC

2.1. Local/Remote selection

Controlling of the DCV700 is based on using combined control words. The words are 16 bit wide and every bit has the defined function like "close the main contactor", "run"-command , "bypass ramp" etc.

There are 2 sets of control words and speed references. One set is for the APC and the second set is for the DDCTool.

When DDCTool commands the drive to "LOCAL", the drive will be switched to use control words and the speed references coming from DDCTool. Otherwise the program always uses command words and speed reference meant of the APC.

The local mode can be blocked for safety reasons with the parameter

ENLOCALSEL (11-15)

0 = enable LOCAL by APC/DI
1 = CMT can command to local any time
2 = disable local

or by one selected digital input with a help of parameter

DI_DISLOCAL (14-01)

0 = enable local
1 = DI4 enables local
2 = enable local
3 = DI6 enables local
4 = DI7 enables local
5 = DI8 enables local

With default settings DDCTool can command the drive to local at any time. The status of the Local-mode can be checked from next signals:

LOCAL_MODE (111- 01) the Local command request from the DDCTool
0 = remote is requested
1 = local is requested

LOCAL (111-02) the actual state of the drive
0 = APC commands the drive
1 = DDCTool commands the drive

The APC application program can also see the state from the bit **B0** on the signal:

AUX_STATUS_WORD (101 05).

B0 = 0 APC commands the drive
B0 = 1 DDCTool commands the drive

2.2. APC -command words

MAIN_CONTROL_WORD - the main control word of DCV 700			index:**10101**
Bit	**Name**	**Value = 1**	**Value = 0**
0			
1	ON	(î) Start fans,field and close the main contactor	Open contactor, stop field and fans
2	RUN	(î)run the drive with selected reference	stop the drive according to STOP_MODE-parameter
3	RESET	(î) acknowledge a fault indic.	
4	COAST	coast stop	
5	SYNC_CMND	(î) synchronising command	
6	SYNC_DISABLE	synchronising is disabled	synchronising is enabled
7	RESET_SYNC_RDY	reset synchronised ready	
8			
9	TRIGG_LOG	(î) external trigger for loggers	
10	WINDOW_CONTROL	Window function enabled	Window function disabled
11	RAMP	Ramp function is used	Variable slope is used
12	FORCE_SP_CNTR	Speed controller I-part is forced	Speed controller I-part is released
13	DIG_OUT4	set DO4 ON	set DO4 OFF
14	DIG_OUT5	set DO5 ON	set DO5 OFF
15	DIG_OUT6	set DO6 ON	set DO6 OFF

Note - (î) edge sensitive signal

AUX_CONTROL_WORD - the auxiliary control word of DCV700			index:**10102**
Bit	**Name**	**Value = 1**	**Value = 0**
0	RESTART_DLOG	(î) restart collecting of data	
1	APC_WATCH_DOG	toggle bit = 1	toggle bit = 0
2	STATIC_RESET	reset bits in static fault/alarm words.	
3			
4			
5			
6			
7			
8			
9			
10			
11			
12	APC_EMESTOP	activate emergency stop seq.	
13	APCDISLOCAL	disable local mode	enable local mode
14	DIG_OUT7	set DO7 ON	set DO7 OFF
15	DIG_OUT8	set DO8 ON	set DO8 OFF

Note - (î) edge sensitive signal

2.3. DDCTool -command words

LOCAL_CONTROL_WORD - the local control word of DCV700			index:**10103**
Bit	**Name**	**Value = 1**	**Value = 0**
0			
1	ON	(î) Start fans,field and close the main contactor	Open contactor, stop field and fans
2	RUN	(î)run the drive with selected reference	stop the drive according to STOP_MODE-parameter
3	RESET	(î) acknowledge a fault indic.	
4	COAST	coast stop	
5			
6			
7			
8			
9	TRIGG_LOG	(î) external trigger for loggers	
10			
11			
12			
13			
14			
15			

Note - (î) edge sensitive signal

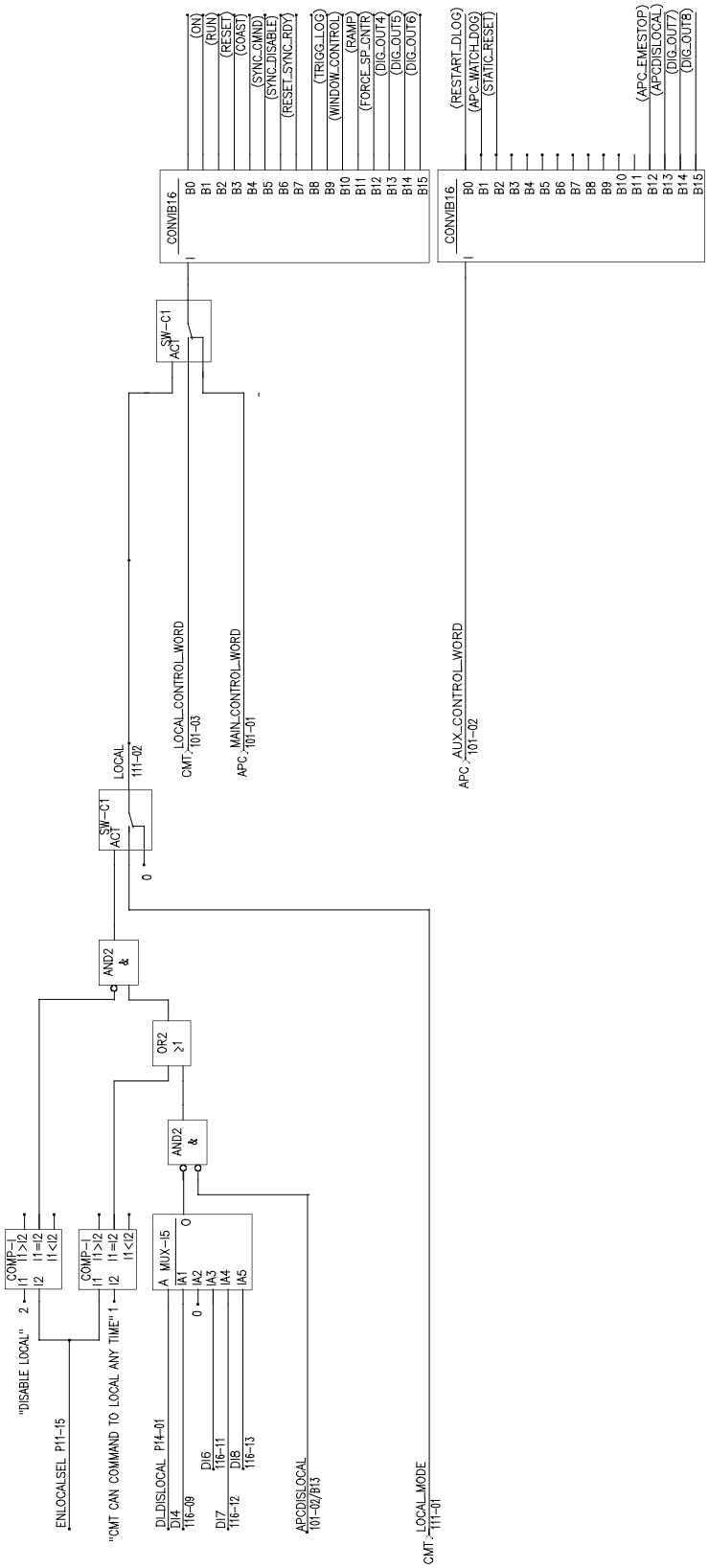


Figure 4 Command words and local mode selection.

2.4. Status words

Status words are used for transferring actual on/off indications from DCV700 to APC.

MAIN_STATUS_WORD - the main status word of DCV700			index:**10104**
Bit	**Name**	**Value = 1**	**Value = 0**
0			
1	RDY ON	ready for close contactor	
2	RDY RUN	ready to generate torque	
3	RUNNING	speed/torque control operating	
4	AUTO-RECLOSING	Auto-recl. logic activated	
5	FAULT	indication of a fault in DCV 700	no fault
6	ALARM	indication of an alarm in DCV700	no alarm
7	TORQUE CONTR	torque control is active	speed control is active
8	SYNC_RDY	synchronised and ready	
9	DI 4	dig input 4 is in ON-state	dig input 4 is in OFF-state
10	DI 5	dig input 5 is in ON-state	dig input 5 is in OFF-state
11	DI 6	dig input 6 is in ON-state	dig input 6 is in OFF-state
12	DI 7	dig input 7 is in ON-state	dig input 7 is in OFF-state
13	DI 8	dig input 8 is in ON-state	dig input 8 is in OFF-state
14	EMERG. STOP	emergency stop is not active	emergency stop is active
15	INH OF F. START	Contactor is open	Contactor is closed

AUX_STATUS_WORD - the auxiliary status word of DCV 700			index:**10105**
Bit	**Name**	**Value = 1**	**Value = 0**
0	LOCAL	local control selected	control from APC
1	LOGG_DATA_RDY	data logger is ready for upload	
2	OUT OF WINDOW	speed error larger than window	speed error less than window
3	SPC IN LIMIT	speed controller output in limit	
4	TREF IN LIMIT	torque reference in limit	
5	TREF_F IN LIMIT	final torque reference in limit	
6	SPREF IN LIMIT	speed reference in limit	
7	FOLLOWER TOUT	follower is not receiving data	
8	ARM_CUR_DER_ LIMITED	armature current ref. rise/fall speed reached limit	
9	CONTINOUS_CURR	Arm. curr. is discontinous	Arm. curr. is continous
10	DCV_WATCH_DOG	toggle bit = 1	toggle bit = 0
11			
12			
13	STATIC_FAULT	indication of a fault-bit in Static Fault Words	
14	STATIC_ALARM	indication of an alarm-bit in Static Alarm Words.	
15			

2.5. Start and stop sequences

The drive is controlled by control and status words. In order to control the drive in a proper way, a "hand shaking" sequence for the logic is necessary. The main functions of the hand shaking sequence is described here.

APC uses **MAIN_CONTROL_WORD** to command the drive, and **MAIN_STATUS_WORD** to read the actual status of the drive

❶-mark with a number describes the order of the instructions.

2.5.1. Start the drive

APC **MAIN_CONTROL_WORD** **101-01**	**DRIVE** **MAIN_STATUS_WORD** **101-04**

When the drive is ready to close the main contactor, the drive sets the bit **RDYON=1**

❶ ⇦ **RDYON = 1**

APC commands "ON"

ON = 1 ⇨ ❷

Drive closes the contactors for the converter and motor fans, the field exciter contactor and the main contactor. After checking network voltage, phase sequence and all acknowledges, program sets the RDYRUN bit.

❸ ⇦ **RDYRUN = 1**

APC commands "RUN"

RUN = 1 ⇨ ❹

Drive releases references and controllers.

❺ ⇦ **RUNNING = 1**

APC controls the running by giving desired speed reference, torque reference etc.

2.5.2. Stop the drive

The drive can be stopped in two ways, either taking off the "ON"-command which opens contactors as fast as possible or by following next sequence:

APC **MAIN_CONTROL_WORD** **101-01**	**DRIVE** **MAIN_STATUS_WORD** **101-04**
APC command "RUN" off **RUN = 0** ⇨	❶
	Drive stops as defined in parameter STOPMODE 11-03. When the drive has reached the zero speed, the drive resets the bit
	❷ ⇦ **RUNNING = 0**
APC can keep "ON" command "1" if it is needed to start the drive rapidly or APC command "ON" off **ON = 0** ⇨	❸
	The main, field and fan contactors are opened
	❹ ⇦ **RDYRUN = 0**

2.5.3. Drive is tripping

If the drive trips, the fan, the field and the main contactor are opened in defined order that depends on the type of the fault. For example if the drive trips to over temperature of the converter , the main contactor and the field contactor are opened but the fan contactor is kept on until the temperature of the bridge falls below the over temperature level of the bridge. Finally all contactors are opened. After this sequence the drive accept the reset-command.

2.5.4. Faults that trip first the main contactor

OVERCURRENT	**-2-**
MAINS UNDERVOLTAGE	**-29-**
NOT IN SYNCHRONISM	**-31-**
ARM_CURRENT_RIPPLE	**-34-**
PHASE_SEQUENCE_FAULT	**-38-**
SPEED_MEAS_FAULT	**-14-**
NO_MAIN_CONT_ACK	**-41-**
MOTOR_STALLED	**-23-**
MOTOR_OVERSPEED	**-37-**

2.5.5. Faults that trip first the main contactor and the field contactor

MOTOR_1_OVERTEMP	**-6-**
MOTOR_1_OVERLOAD	**-7-**
MOTOR_2_OVERTEMP	**-48-**
MOTOR_2_OVERLOAD	**-27-**
CONVERTER_OVERTEMP	**-4-**
APC WATCH-DOG ERROR	**-21-**
NO C FAN ACK	**-50-**

2.5.6. Faults that trip the main, the field and the fan contactors

AUXIL.UNDERVOLTAGE	**-1-**
ARMATURE OVERVOLTAGE	**-28-**
EARTH_FAULT	**-5-**
I/O BOARD NOT FOUND	**-44-**
MAINS OVERVOLTAGE	**-30-**
FIELD EX 1 OVERCURR	**-32-**
FIELD EX 1 COMERROR	**-33-**
FIELD EX 2 OVERCURR	**-35-**
FIELD_EX_2_COMERROR	**-36-**
NO_FIELD_ACK	**-39-**
NO_EXT_FAN_ACK	**-40-**
TYPE_CODING_FAULT	**-17-**
PAR_BACKUP_FAULT	**-18-**
APC_LINK_COMM_ERROR	**-20-**
FIELD_EX_1_NOT_OK	**-42-**
FIELD_EX_2_NOT_OK	**-43-**

2.5.7. Fault resetting

The drive is reset by the "RESET"-bit in MAIN_CONTROL_ WORD. The drive notices the rising edge of the signal. To be able to restart the drive after tripping, a rising edge must be formed to the "ON" and "RUN" signals. The technique prevents the "RESET" signal to command contactors "ON" by itself.

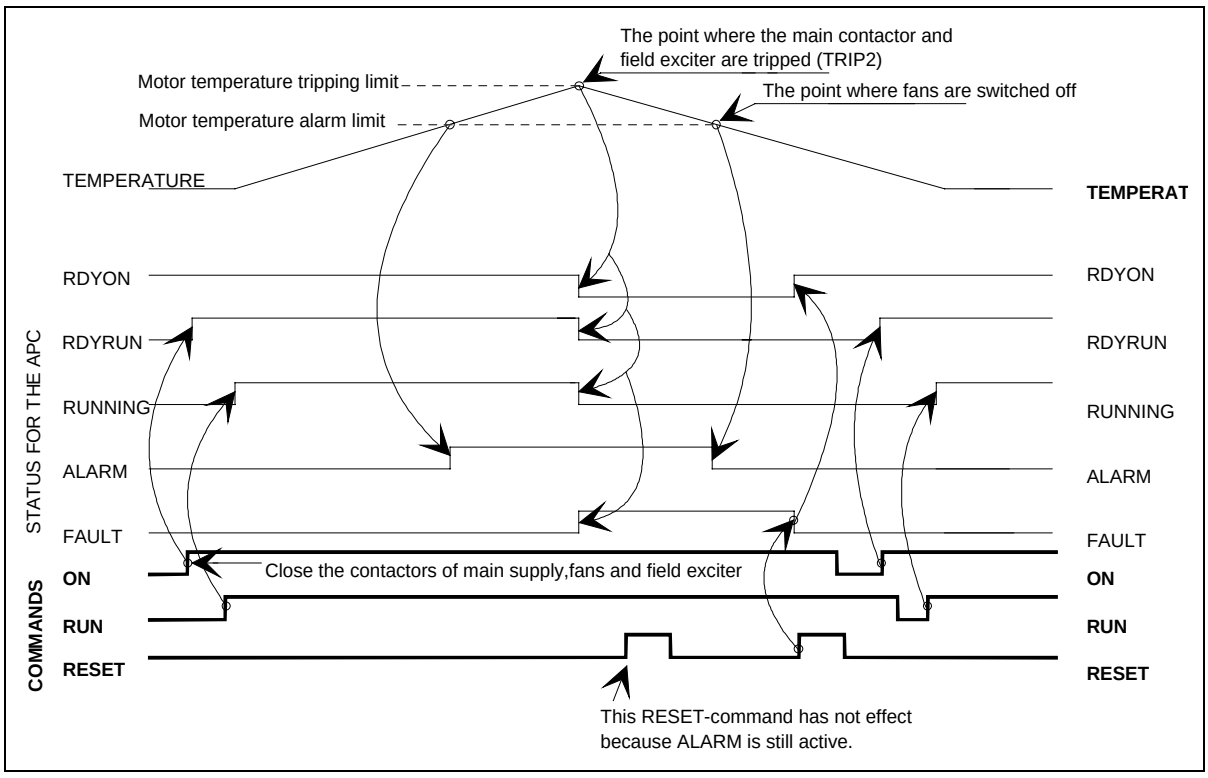


Figure 5 Example of the behaviour of the program in a case of over temperature fault.

2.6. Emergency stop

Emergency stop can be activated by

the digital input **DI5**
AUX_CONTROL_WORD 101-02 bit 12 from APC.

The function of the DCV700 when emergency stop is activated, can be defined by the parameter **EMESTOPMODE (11-05)**. Default mode is **stop with ramp**.

EMESTOPMODE (11-05)

0 = stop with ramp (default)
1 = stop by the torque limit
2 = coast stop (torque is zero)
3 = dynamic brake

The time in which the drive will decelerate from maximum speed to zero during emergency stop is set by the parameter

EMESTOP_TIME (2-04),

The signal **EMERG_STOP (114-09)** indicates the status of the emergency stop. This signal is connected to the digital output **DO4** as default.

During emergency stop the ramp smoothening function ,if activated, is by-passed.

3. MEASUREMENTS

3.1. Speed measurement

The speed of the motor can be measured by three different methods; incremental encoder (pulse tachometer), analogue tachometer or calculated/measured EMF-voltage. Speed reference 20000 corresponds to the maximum speed of the motor, the sign indicates the direction of the speed. The forward direction sign is (+) , and the reversal direction sign is (-) .

The speed measurement mode is selected by the parameter

SPEED_MEAS_MODE (18-04) 0...3 incremental encoder
4 AI channel AITAC is used
5 speed act calculated by EMF

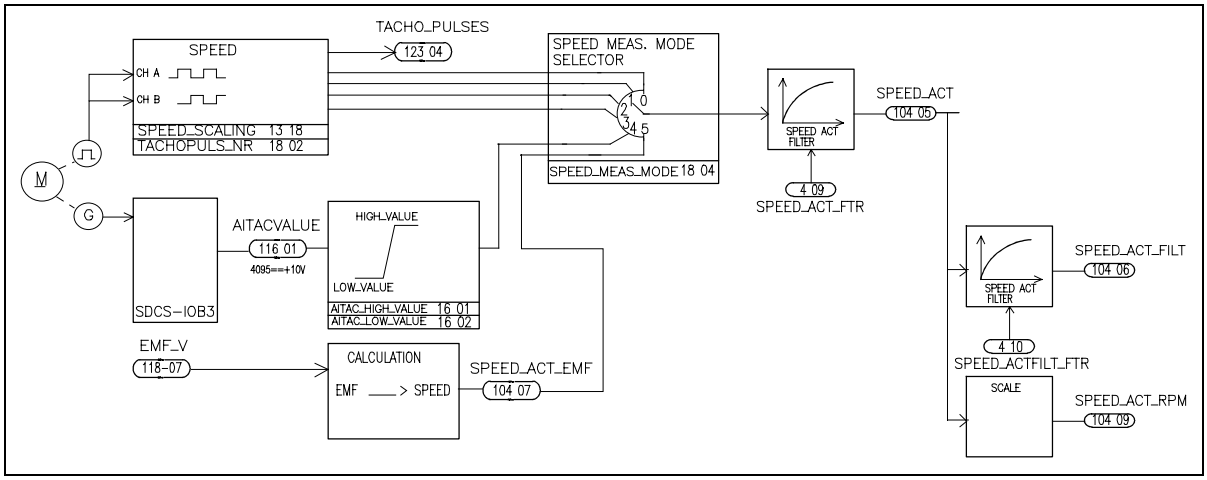


Figure 6 The actual speed measurement.

3.1.1. Scaling of the speed measurement

The base scaling for the speed as units is 20000.
The maximum speed of the drive is set by the parameter

SPEED_SCALING (13-18)

with the resolution of 0.1 rpm

3.1.2. Pulse encoder

The incremental encoder can be used as one or two channel encoder. The range of tacho pulses per revolution is 125 - 6000. Selection of the speed measurement mode depends on the type of the pulse encoder:

SPEED_MEAS_MODE (18-04)

0 = ch A: positive edges for speed; ch B: direction
1 = ch A: positive and negative edges for speed; ch B: not used
2 = ch A: positive and negative edges for speed; ch B: direction
3 = ch A: ch B: all edges are used

Modes 0 ,1,2 are not recommended !

Number of pulses per revolution for the used pulse encoder is set by the parameter

TACHOPULS_NR (18- 02) = 2048 (def.)

Number of pulses received from pulse encoder can be monitored by the signal

TACHO_PULSES (123-04).

3.1.3. Analog tachometer

The signal of the analogue tachometer is recommended to scale so that the input value of the AITAC-channel at the maximum speed of the motor is below 8 V. This provides safety marginal for possible instantaneous overspeed because the conversion area of the AITAC-channel is 10 V.

The analogue tachometer is selected by setting

SPEED_MEAS_MODE (18-04) = 4

The scaling of the analogue channel for the speed is done by two parameters. The set values are ***speed units*** which are wanted to equal the measured input voltage +/- 10V.

AITAC_HIGH_VALUE (16-01)	Value that corresponds to input +10 V). Default 30000
AITAC_LOW_VALUE (16-02)	Value that corresponds to input -10 V) Default -30000

The polarity of the analogue channel can be checked by turning the motor slowly and at the same time checking the signal **AITACVALUE (116-01)**. Values 4095 equals to input 10 V.

3.1.4. EMF-based speed measurement

The motor speed can be controlled without an external measurement by using the EMF-measurement for the speed calculation. This can be done when the motor is driven at a constant field area.

The **SPEED_ACT_EMF (104-07)** is calculated as follow:

SPEED_ACT_EMF = EMF_V * FIELD_WEAK_POINT / U_MOTN_V

The scaling of the EMF-speed can be done by adjusting the parameter **U_MOTN_V (13-01)**. Normally the value should be 10...15% less than the rating plate value of the motor (DC) voltage. That is because the rating plate value includes also losses coming from the IR drop.

3.1.5. Speed actual measurement points

Three measurement points are available for monitoring the speed actual.

SPEED_ACT (104-05)	Used for speed control. Can be filtered by setting time constant to the parameter **SPEED_ACT_FTR (4-09)**, scale: 1==1ms.
SPEED_ACT_FILT (104-06)	Used for displays like DDCTool Can be filtered by means of the parameter **SPEED_ACT_FILT_FTR (4-10)**, scale: 1==1ms.
SPEED_ACT_RPM (104-09)	Used for DDCTool displays.

3.2. Armature current measurement

DC-armature current is measured on the AC-side using the current transformer. The measured AC -current is rectified and scaled to the DC-voltage signal so that 1.5V in SCDS-CON-1 board equals ***always*** the nominal current of the converter.

The measured current is scaled in two ways. The overcurrent protection needs the current measurement which is scaled so that the ***converter*** nominal current equals 4095.
The ***control of the motor*** is scaled so that 4095 equals the nominal current of the motor.

3.2.1. Converter current

Converter current is relative to the nominal current of the converter.
The converter current is used for overcurrent protection.

CONV_CUR_ACT **(118-05)**	Converter armature current. 4095 equals to nominal converter current.
CONV_CUR_ACT_A **(118-06)**	Converter current as amps. 1 = 1A

3.2.2. Armature current

Armature current is relative to the nominal current of motor.
The measurement is divided into two signals where the sign of the signals is handled differently in order to facilitate diagnosing.

ARM_CUR_ACT **(107-08)**	Measurement for the current controller **4095 = I_MOTN_A (13-02)** The sign of this signal indicates **+ = forward bridge in use** **- = reversal bridge in use**
MOT_CUR_ACT **(107-07)**	Measurement for diagnosing **4095 = I_MOTN_A (1302)** The sign of this signal indicates **+ = motor mode** **- = generator mode**

3.3. Torque

The calculation of actual torque is based on flux and armature **(=motor)** current. With nominal armature current (4095) and nominal flux (4095) the actual torque is nominal.

TORQ_ACT (107-06)	The torque of the motor in units 4000 =Tn(motor)
Generally $T = I_A *$, where	T= torque I_A = armature current = flux

3.4. Network AC voltage

Measured network voltage is used for the armature current control and the mains under/over voltage supervision. If network voltage changes, current control will adjust the firing angle so that armature voltage stays in the desired level .

U_NET_ACT (118-01)	4095 = **U_SUPPLY (18-06)**
U_NET_ACT_V (118-02)	1 = 1V

3.5. Armature DC voltage

Measured armature voltage is scaled so, that 4095 = 1.35***U_SUPPLY (18-06)**. This value is used for calculation of actual value of EMF.

U_ARM_ACT(118-03)	4095 = 1.35***U_SUPPLY (18-06)**
U_ARM_ACT_V(188-04)	1 = 1V

3.6. Actual EMF

The relative value of EMF is used for EMF-control and for the EMF-based speed measurement . EMF is calculated with a formula that takes into account both the inductive and resistive voltage drops:

$$EMF = U_{dc} - (I_A * R_A + dI_A / dt * L_A)$$

Actual relative EMF can be read from the signal

EMF_ACT(108-06), where 3786 = 1.35***U_SUPPLY(18-06)**.

The signal

EMF_V (118-07) gives EMF in volts.

Normally the Auto-tuning facilities calculate the resistance and inductance values of the motor . The values can also be defined manually using next formulas:

The relative resistance of armature circuit **ARM_R (13-12)**:

$$ARM_R = 22444 * RA[\Omega] * \frac{I_CONV_A(11301)}{U_SUPPLY(1806)}$$

where RA[]=armature resistance

The relative inductance of armature circuit **ARM_L (13-11)**:

$$ARM_L = \frac{LA[mH] * I_CONV_A(11301) * 245}{U_SUPPLY(1806) * scantime}$$

where LA[mH] = armature inductance in mH
sample time = 3,33 ms (50 Hz network) or 2,77 ms (60 Hz)

3.7. Field current

Two field exciters are possible to connect to one converter unit. (2) DCF503/504 or (1) SDCS-FEX-2 plus (1) DCF503/504.
From both field exciters there are two measurements available, relative and absolute current values.

3.7.1. Motor 1 field current

FIELD1_CUR_ACT (118-10) — Motor 1 actual relative field current
4095= **I_MOT1_FIELDN_A (13-03)**

FIELD1_CUR_ACT_A (118-11) — Motor 1 actual absolute field current in amps.
1=0.01 A

3.7.2. Motor 2 field current

FIELD2_CUR_ACT (118-12) — Motor 2 actual relative field current
4095= **I_MOT2_FIELDN_A (13-17)**

FIELD2_CUR_ACT_A (118-13) — Motor 2 actual absolute field current in amps.
1=0.01 A

3.7.3. Customer supplied field exciter

When a customer supplied field exciter is used the field current feedback is connected to an analogue or digital input. Analogue input is used if it is needed to measure or control field current, digital input when only field acknowledge is needed. The analogue channel must be scaled so, that the input corresponds to field current.

3.8. Cooling unit temperature

Actual temperature of the heat sink can be monitored from the signal

BRIDGE_TEMP (118-14), where 1 is equal to 1C.

4. SPEED REFERENCE CHAIN

The speed values (ref./act.) are scaled so that 20000 equals to the maximum speed of the drive.
The speed reference chain consist of next items:

- Speed reference selection
- Speed ramp
- Speed reference limitation
- Additional speed reference
- Ramp smoothen function
- Acceleration compensation

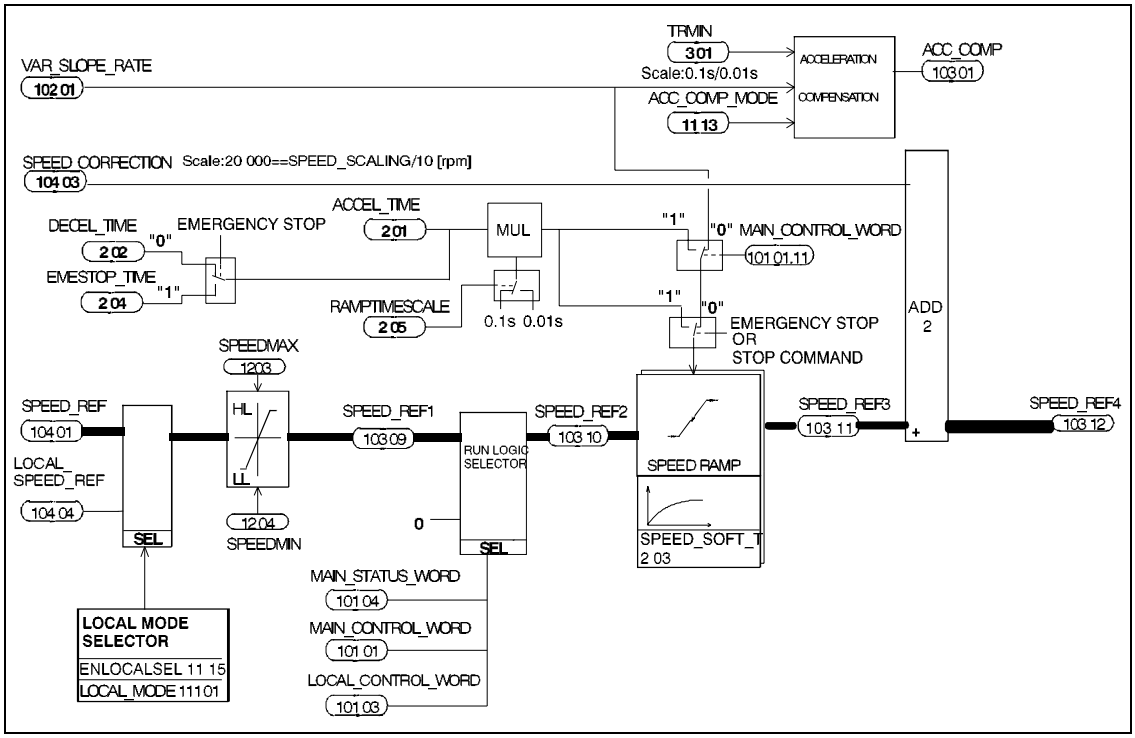


Figure 7 The speed reference chain.

4.1. Speed ramp

The speed reference value **SPEED_REF2 (103-10)** is passed through the speed ramp function. The ramp function is selected when the bit **MAIN_CONTROL_WORD (10-101.ramp)** is set to "1". When using the DDCTool the ramp function is always used.

Acceleration and deceleration times can be set by parameters:

ACCEL_TIME (2-01)	The time in which the drive will accelerate from zero speed to maximum speed. Scaling: 1 = 0.1 sec.
DECEL_TIME (2-02)	The time in which the drive will decelerate from maximum speed to zero. Scaling: 1 = 0.1 sec.

In case of the emergency stop, a different ramp down time can be chosen by the parameter

EMESTOP_TIME (2-04)	The time in which the drive will decelerate from maximum speed to zero. Scaling: 1 = 0.1 sec.

If 0.1 sec resolution for the ramp is too inaccurate, you can select a more accurate base scale for the ramp times by the parameter

RAMPTIMESCALE (2-05)	The time scale for the ramp 100 = time resolution is 100 ms 10 = time resolution is 10 ms

4.2. Variable slope

The APC can control the slope of the DCV700 ramp if the more complicated ramp function is needed. The base idea is that APC has the system main ramp. When APC calculates the new value for the ramp, APC derives also the derivative of the ramp. This is simply the difference between the present ramp output and the previous one. The serial communication transfers in synchrony both the new speed reference value and the slope value to the DCV700. The DCV700 receives in this case the new speed reference and the slope time how fast the DCV700 must go towards the new reference.

When stop-command or Emergency stop is given, the DCV700 returns always to use defined ramp slope times.

The variable slope function is selected when the bit **MAIN_CONTROL_WORD (101-01.ramp)** is set to "0".

The speed of the slope can be given by the signal

VAR_SLOPE_RATE (102-01)	The speed of the slope when variable slope is in use. scale: speed scale unit/100 ms 0 = fastest , (ramp is by-passed) 2000 = 0...20000 in one sec.

4.3. Ramp output smooth function

The output of the speed ramp function can be softened by filters. The influence can be adjusted by parameter **SPEED_SOFT_T (2-03),** scaling: 1 = 1 ms.

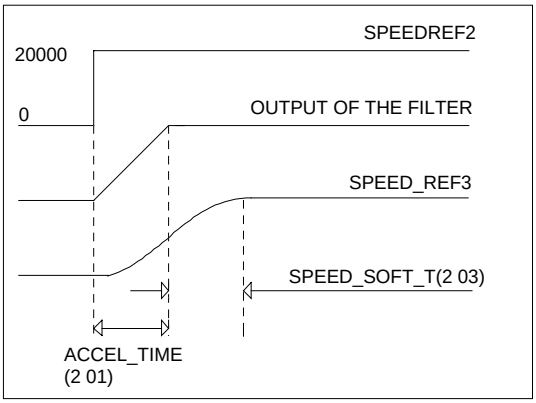


Figure 8 Effect of speed ramp and filters.

4.4. Acceleration compensation

An additional torque for the acceleration compensation can be calculated by the DCV 700 when the inertia of the drive is known and the inertia is constant. Such systems like uncoilers where the inertia changes must be calculated by APC.
The compensation is calculated when the ramp function is released. When the ramp function is by-passed, like stop by torque limit, the acceleration compensation output is clamped to zero.
The selection of acceleration compensation is made with the parameter

ACC_COMP_MODE (11-13)
0 = not used
1 = compensation calculation activated

The time in which the drive will accelerate from zero speed to nominal speed using 100% torque must be calculated and then set to the parameter

TRMIN (3-01)
The time in which the drive will accelerate from zero speed to maximum speed using motor nominal torque (T_N)

The output of acceleration compensation function can be seen in signal

ACC_COMP (103-01)
Scale: 4000 = motor nominal torque (T_N)

5. SPEED CONTROL

Controlling of the motor speed is based on PID-type controller. In addition to PID there are also certain functions in order to facilitate the adjustment of the PID-controller to the demands of the various processes. The main functions to control the motor speed are:

Speed error filter
Speed error window (in case of Master/Follower sections)
Step response signals for DDCTool
PID -controller
Drooping
Adaptive load dependent P-gain
PID output limitation

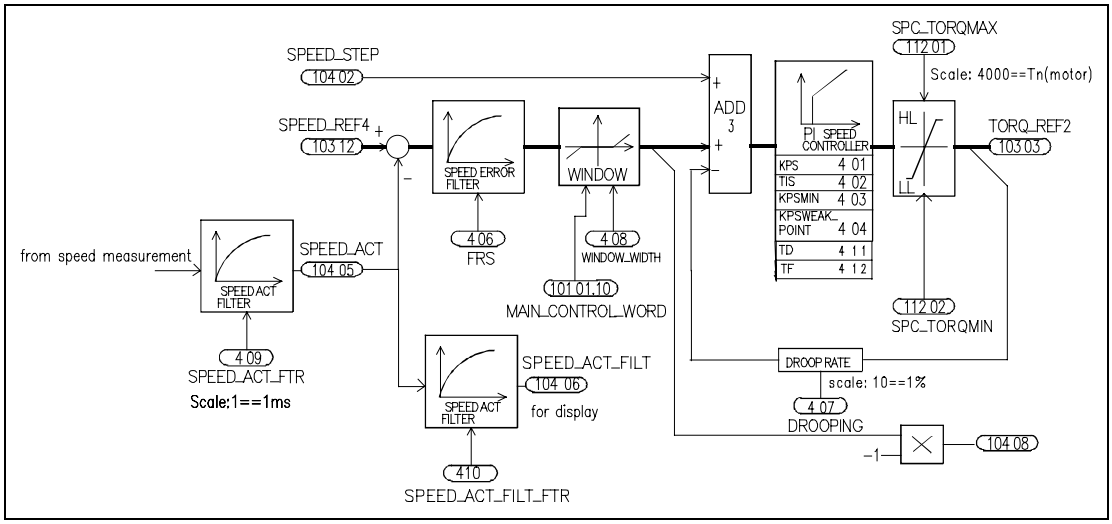


Figure 9 Speed error filter and the window control.

5.1. Speed error filter

The **SPEED_REF4 (103-12)** is used as the speed reference and the **SPEED_ACT (104-05)** is actual speed from the speed measurement.

The error value can be filtered by the low-pass filter. The time constant is given by the parameter

FRS (4-06).

Scaling is 1 = 1 ms.

5.2. PID-controller

For tuning of the PID four parameters are needed:

KPS **(4-01)**	The proportional gain of the speed controller Scaling: % (100 = 1.)
TIS **(4-02)**	The integrator time constant Scaling: ms. (1000 = 1s)
TD **(4-02)**	Time Derivation. The time constant for derivation. Scaling: ms. (1000 = 1s)
TF **(4-02)**	Time Filter. The filter time constant for derivation. Scaling: ms. (1000 = 1s)

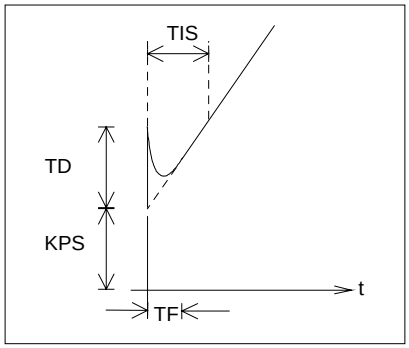


Figure 10 *The step response of the PID-controller*

5.3. Adaptive P-gain

The P-gain of the controller can be reduced automatically when the load is small. This is sometimes necessary when the mechanic part has a slack somewhere.

The proportional gain when the controller output is zero is defined by the parameter:

KPSMIN **(4- 03)**	Scaling: % (100 = 1)

The amount of the load where P-gain is the same as KPS is set by the parameter:

KPSWEAKPOINT (4-04) Scaling: speed unit. 20000 = max. speed.

When load is between zero and KPSWEAKPOINT, the used P-gain is interpolated .
The P-gain cannot be changed too fast. For this reason there is a filter between calculated P-gain and used P-gain. The time constant for this filter can be set by parameter:

KPSWEAKFILT (4-05) Scaling: ms.

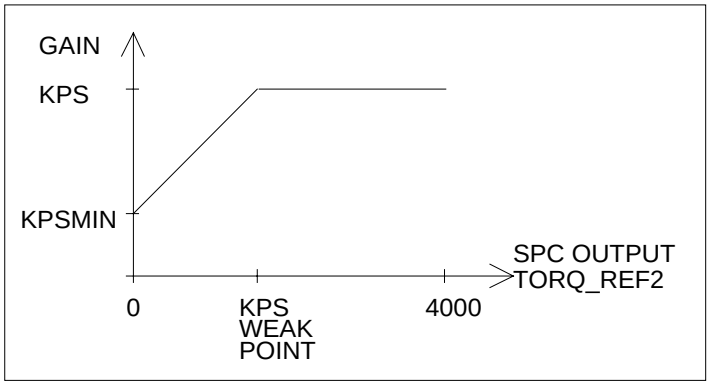


Figure 11 P-gain reduction as a function of torque reference

5.4. Force speed controller output

APC can set the speed controller output, if needed. The set-value is given by the signal

SPEED_C_FORCE_VAL (103-08) Scale: 4000 = motor nominal torque

The force-command is given by setting or resetting the bit **FORCE_SP_CNTR** in the signal

MAIN_CONTROL_WORD (101 01.12)

10101.12 = 1 The output of the speed controller is forced
10101.12 = 0 The speed controller is released

5.5. Drooping

The drooping function is used when there is a need to adapt the speed proportionally to the load.

The amount of speed decrease caused by the load is determined by parameter

DROOPING (4-07)	Scaling: 10 = 1% the nominal torque reference will decrease the speed by 1%.

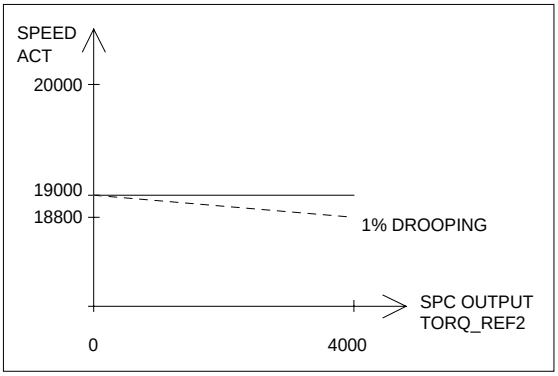


Figure 12 Drooping as a function of torque reference.

5.6. Window control

The window control is used when master/follower connections are needed.

The purpose of the window control is to keep the speed of the slave section inside defined (speed)window.

When window control is activated the speed controller is forced to zero as long as the speed deviation remains within defined limits.

In window control mode the speed controller output and the external torque reference are added together. The adding is done when the parameter

TORQ_SEL (11-01) = 5

The window size is determined by the parameter

WINDOW_WIDTH (4-08)	Scaling: speed unit 20000 = nominal speed

The program calculates values for the MinWindow and MaxWindow as follows:
MaxWindow = WINDOW_WIDTH/2
MinWindow = - MaxWindow

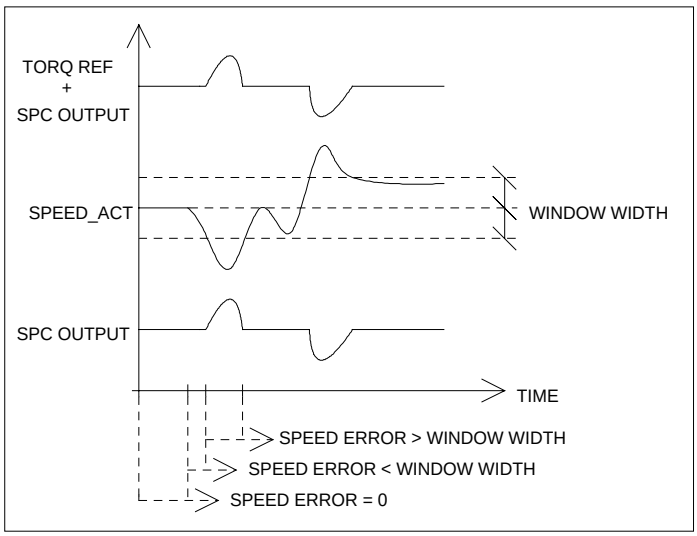


Figure 13 Effect of load change on a torque controlled drive in window control

The window control mode is selected by setting the bit WINDOW_CONTROL in the signal

MAIN_ CONTROL_WORD (101-01.10)

10101.10 = 1	the window control is enabled. The program sets automatically the integral time constant TIS to zero. *In the window control mode the speed controller works only as a P-control.*
10101.10 = 0	the window control is disabled.

APC can supervise how well the drive stays inside given window by reading the bit OUT_OF_WINDOW in the

AUX_STATUS_WORD (101- 05.2)

10105.2 = 1	The speed is out of the given window
10105.2 = 0	The speed is inside the given window

6. TORQUE REFERENCE

DCV700 has two inputs for the external torque reference. The handling features of the external torque references are

Torque scaling (load sharing)
reference filtering
ramp for the torque reference
torque reference limitation

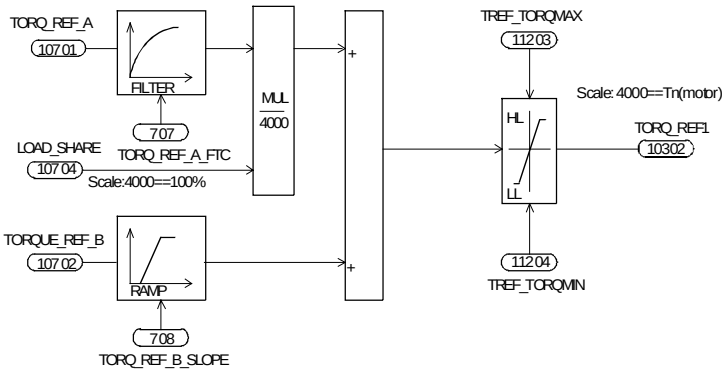


Figure 14 Torque reference modification

6.1. External torque reference A

The channel A can be filtered and scaled. The reference is written to the signal

TORQ_REF_A (107-02)	Scale: 4000 = nominal torque of the motor

The time constant for the filter is set by parameter

TORQ_REF_A_FTC (7-07)	Scale: ms 1000 = 1 s

The scaling of the torque reference is done by signal

LOAD_SHARE (107-04)	Scale: torque unit 4000 = 100%

6.2. External torque reference B

The channel B has a ramp function. The reference is written to the signal

TORQ_REF_B (107-02)	Scale: 4000 = nominal torque of the motor

The time for the ramp is set by parameter

TORQ_REF_B_SLOPE (7-08)	Scale: ms 1000 = 1 sec 0 = ramp is by-passed

6.3. External torque reference limitation

Both above mentioned references are added together and then limited. The sum of the references can be measured from the signal

TORQ_REF1 (103-02)

The torque references are limited by the signals

TREF_TORQMAX (112-03)	Scale: 4000 = nominal torque of the motor Factory set value: 16000
TREF_ TORQMIN (112-04)	Scale: -4000 = nominal torque of the motor Factory set value: -16000

APC can check the status of the limitation by reading the bit 4, TREF_IN_LIMIT in the

AUX_STATUS_WORD (101-05.4)

10105.4 = 1	The torque reference is in the limit
10105.4 = 0	The torque reference is between the limits

7. TORQUE REFERENCE CHAIN AND SELECTOR

DCV700 offers versatile possibilities for selecting the torque reference between speed controller output and an externally given torque references. These are:

Speed controlled
External torque reference controlled
Minimum selector, either speed control or external torque reference
Maximum selector, either speed control or external torque reference.
Window controlled

When the drive is controlled by the external torque reference, the output of the speed controller is updated by the used torque reference value. This allows a bumbles transfer from the torque controlled mode to the speed controlled mode.

7.1. Torque reference selector

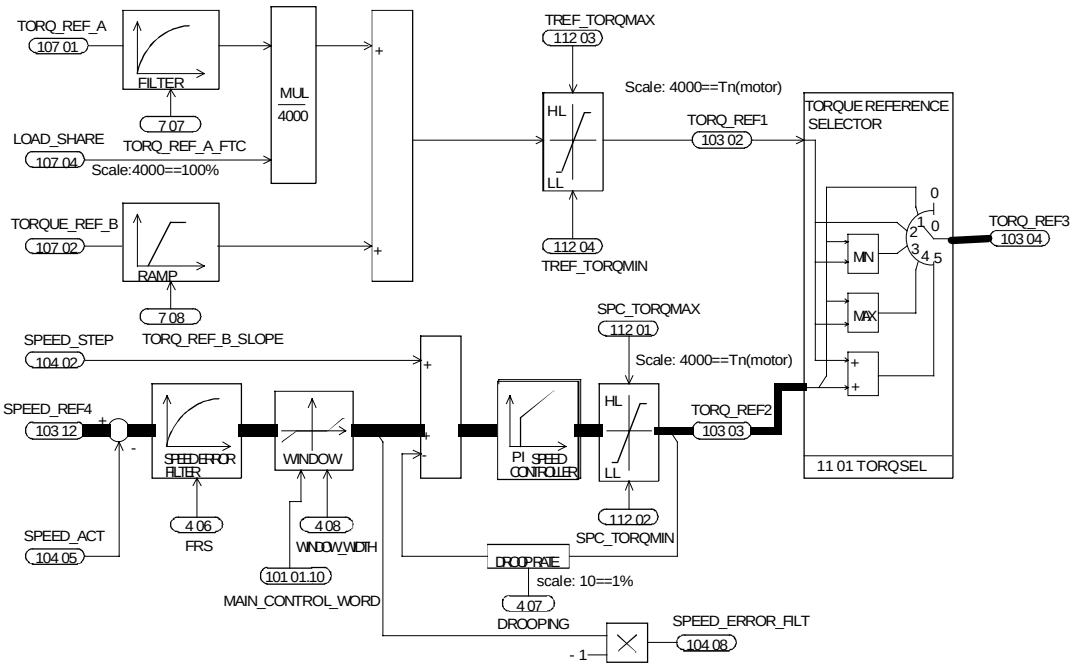


Figure 15 Torque reference selector

The operation mode of the torque control is selected by the torque reference selector. The selection mode is set by means of parameter

TORQSEL (11-01)

0= no torque or speed control.

1= The output of the speed controller is selected to the torque reference. (**TORQ_REF2 ,(103-03)**)

2= The external torque reference is selected to the torque reference. **(TORQ_REF1 ,(103-02))**

3= selects minimum value on the basis of the speed difference.
A negative speed difference (**SPEED_REF4 < SPEED_ACT**) causes a change-over to speed control. A change-over from speed control to ext. torque ref. takes place when the torque reference is smaller than the speed controller output, (**TORQ_REF1<TORQ_REF2** and **SPEED_REF4>= SPEED_ACT**).

4= selects maximum value on the basis of the speed difference.
A positive speed difference (**SPEED_REF4 > SPEED_ACT**) causes a change-over to speed control. A change-over from speed control to ext. torque ref. takes place when the torque reference is greater than the speed controller output,
(**TORQ_REF1> TORQREF2** and **SPEED_REF4 <= SPEED_ACT**).

5= Window control, external torque reference and speed controller output are added together.

APC can read the status of the torque selector by reading the bit TORQUE_CONTR in the

MAIN_STATUS_WORD (101-04)

1== torque control is active,
0==speed control is active.

7.2. Torque reference chain

After the selection of the torque reference source, the program can add certain signals to the reference. These signals are:

- Torque Step
- Load Compensation
- Acceleration compensation

After adding the reference is limited. The bit **TREF_IN_LIMIT** (5) in the **AUX_STATUS_ WORD(101-05)** informs when **TORQ_REF5 (103-06)** is in the limit.

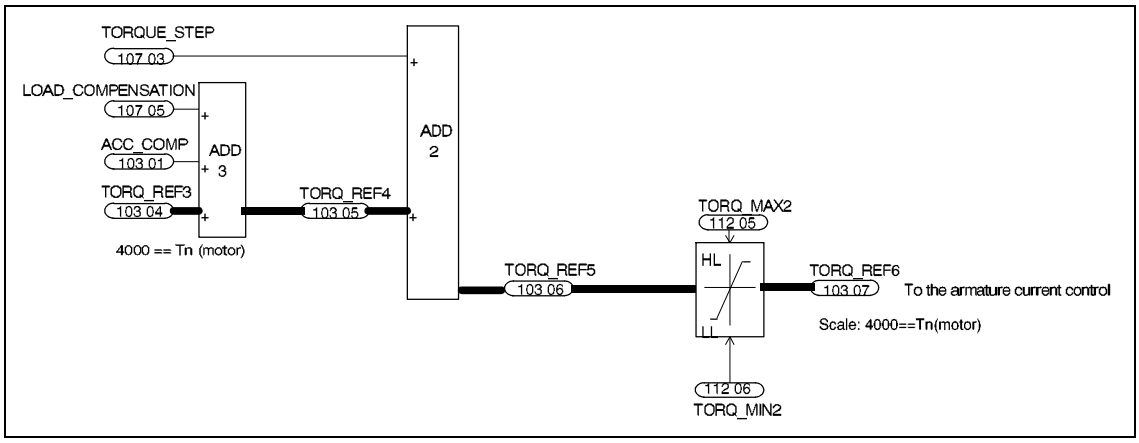


Figure 16 Torque reference chain.

8. ARMATURE CURRENT CONTROLLER

The current controller part of the software controls the armature current of the motor and forms firing pulses needed for thyristors. Main parts of the armature current controller are:

Scaling from torque reference to current reference
Current reference slope
PI -controller
Alpha limitation
DXN, the load dependent beta-limit
Firing unit

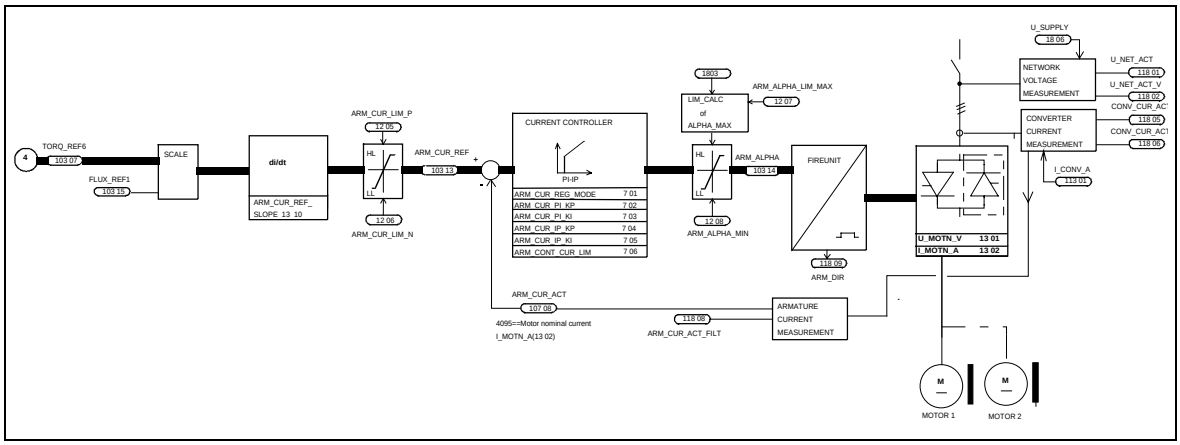


Figure 17 The armature current reference and controller

8.1. Reference scaling

The torque reference is scaled to the current reference by taking into account the flux reference.

With the nominal flux (4095) and nominal torque (4000) the current reference is nominal of the motor.

The scale of the current reference:

4095==given data of motor **I_MOTN_A**.

8.2. Reference slope

The rise time of the current reference can be adjusted. That can be used if fast rise time causes problems to the motor commutator. The rise time is defined by the parameter

ARM_CUR_REF_SLOPE (13-10)	Scale: current units / 3.3 ms [50 Hz] Default: 1366 33 % / 3.3 ms [50 Hz] (scan time 2.77 ms [60 Hz])

8.3. Reference limitation

The current reference is limited by the parameters

ARM_CUR_LIM_P (12-05)	Positive (motor bridge) current limit Scale: 4095 = motor nominal current
ARM_CUR_LIM_N (12-06)	Negative (motor bridge) current limit Scale: **-** 4095 = motor nominal current

Additionally the current reference can also be limited proportionally to the motor speed.

8.4. Armature current deviation alarm

If the current controller cannot yield to the given reference, the alarm signal is created. Normally the reason is too small AC voltage compared to the motor EMF.

If the difference between the **ARM_CUR_REF(103-13)** and the **ARM_CUR_ACT (118-07)** is bigger than 20% of nominal longer than 5 seconds the alarm

ARM_CUR_ DEV_ALARM -120-

will be generated. The drive is not tripped for this reason.

8.5. Armature current controller

The armature current regulator has two controlling methods. These are PI-controller and IP- controller.

The IP -controller is not recommended to use.

The selection between these types can be done , if wanted, by means of the parameter

ARM_CUR_REG_MODE (7-01) Selection of the control method.

0= PI-regulator
KP = ARM_CUR_PI_KP (7 02)
KI = ARM_CUR_PI_KI (7 03)
1= IP-regulator
KP = ARM_CUR_IP_KP (7 04)
KI = ARM_CUR_IP_KI (7 05)

The parameters for the PI controller can be selected either using the autotuning feature or by manual tuning. The parameters of the IP controller cannot be set on the basis of the usual criteria, the autotuning feature is always needed.

8.5.1. Scaling of PI - controller

.

PI-controller is scaled so that the P-gain value 100% produces the same value to the output as can be seen in the input.

P-gain:

$$\text{output} = \frac{\text{ARM_CUR_PI_KP} * \text{error}}{256}$$

So default value 300 is equal than gain 300/256=1.17 (117%)

I-gain:

Integral time constant :

$$\text{ARM_CUR_PI_KI} = 16384 * \frac{\text{scantime}}{\text{TC}}$$

where scan time = 3.33 ms in 50 Hz network
= 2.77 ms in 60 Hz network
TC = time constant in ms.

8.5.2. Discontinuous/Continuous current limit

The current controller demands that the discontinuous current limit is defined. The limit is defined by parameter

ARM_CONT_CUR_LIM (7-06) ***converter actual current*** in the point where armature current changes from discontinuous to continuous current.

The autotuning feature will define the point automatically.

With the manual tuning the point must be measured from the armature circuit using e.g. oscilloscope.

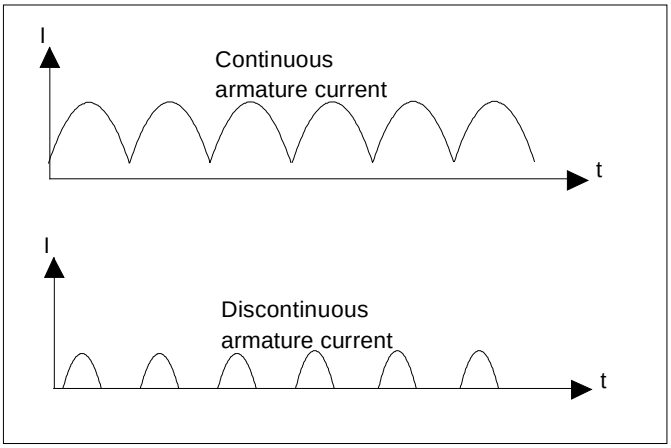


Figure 18 Wave forms of the armature current.

The discontinuous current state can be measured by reading the bit **CONTINOUS_CURR** in the signal

AUX_STATUS_WORD
(101-05.9)
1 = Armature current is discontinuous
0 = Armature current is continuous

8.6. Alpha limitation

The current controller output is transferred to the firing unit. The actual firing angle can be measured from the signal

ARM_ALPHA	Scale: degrees
(103-14)	150 = 150

Limits for the firing angle are set by parameters

ARM_ALPHA_MIN	Minimum firing angle
(12-08)	Scale: degrees default value = 15
ARM_ALPHA_MAX	Maximum firing angle
(12-07)	Scale: degrees default value = 150

8.7. Additional commutation reserve DXN

The commutation cannot take place infinitely fast because of the network reactance. The time for the commutation can be expressed by the commutation angle u, which can be calculated using formula:

u = arc cos (cos - I_d/I_k) -

where I_k = short circuit current
I_d = load current

The DXN is the proportional network short circuit voltage caused be the ***converter nominal current***.

$$DXN = \frac{2 * Xk * I_CONV_A}{\sqrt{2} * U_SUPPLY} * 1000$$

The value for the extra commutation reserve is set to the parameter

DXN Scale: 0.1 of the U_SUPPLY
(18-03) default value =0.

To avoid shooting trough of the converter, the adjusted values of alpha should only be changed after consultation with ABB.

8.8. Bridge selection monitoring

The bridge used during running can be monitored by the signal

ARM_DIR (118-09)

0 = no bridge
1 = motor bridge
-1= generator bridge.

9. FIELD EXCITATION

DCV700 has a possibility to use several kind of field exciters or combination of them, depending on application. This chapter explains the basic differences of various field exciters. Functions which are using field exciters are also explained in this chapter.

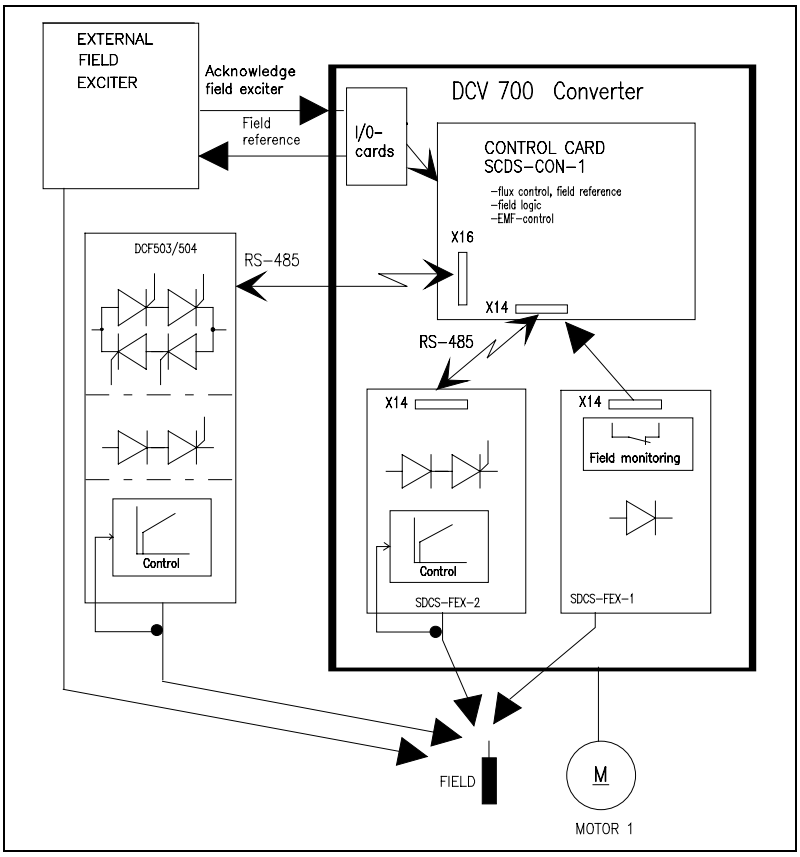


Figure 19 Basic parts of the field excitation.

9.1. Field exciter type selection

The used type of the field exciter is selected by parameter

FEXC_SEL (11-10)

0	No field exciter selected
1	Internal diode field exciter SDCS-FEX-1
2	Internal SDCS-FEX-2 or ext. DCF503/504
3	external DCF503/504 as a second field exciter
4	internal SDCS-FEX-2 or ext. DCF503/504 as a first field exciter and external DCF503/504 as a second field exciter.
5...8	other field exciter, acknowledge through DIx
9...13	other field exciter, acknowledge through AIx

The program by-pass the field acknowledge signal when "No field exciter" is selected. This selection is meant for testing purposes.

First field exciter and second field exciter are used with a function "Shared motion".

9.2. Internal diode field exciter SDCS-FEX-1

The current setpoint when using SDCS-FEX-1 is selected by adjusting appropriate voltage output from the field autotransformer. The program does not measure the current value but an acknowledge signal is formed that supervises whether the field exciter has current or not. More parameter settings are not needed. The acknowledge signal cannot be read directly but if the signal **TCRDYRUN (110-03)** stays zero more than 6 second after "ON" - command is given, the drive will trip to the fault: **NO FIELD ACK -39-**.

9.3. Internal field exciter SDCS-FEX-2

Internal field exciter SDCS-FEX-2 is a half controlled bridge that can control the field current with one (positive) direction. Because of the nature of the half controlled bridge, a very small amount of current (5...10%) flows always through the bridge if the field contactor is closed. SDCS-FEX-2 is controlled via the serial communication link. SDCS-FEX-2 measures field current and sends the value to the drive via serial communication. The measured field current is used to form acknowledge signal. If the field current reach too big level, the drive will trip to the fault **FIELD EX 1 OVERCURR -32-**. Too low level blocks the controllers immediately and the drive will trip to the fault: **NO FIELD ACK -39-**. At start the program waits 6 second before tripping in order to give time for producing field.

9.4. External field exciter DCF504

External field exciter DCF504 can control the field current both in positive and negative direction. Which direction is wanted is defined by the sign of the field current reference. A positive sign means "forward" bridge and negative sign "reverse" bridge.
The field current supervision logic is handled in a similar way than with SDCS-FEX-2.

9.5. External field exciter DCF503

For the control point of view DCF503 is similar than SDCS-FEX-2. The differences are that DCF503 can handle bigger field current than SDCS-FEX-2 and it is mechanically bigger.

9.6. AI/DI -based field exciters

When modifying already existing machines (so called revamping) it is quite often wanted to keep the existing field exciter. In this case an acknowledge signal must be formed in order to supervise the field function. This can be done either using one DI or AI.

9.6.1. Use of DI-channel

When DI is used to form acknowledge signal, the function is similar than when using SDCS-FEX-1, diode field exciter. The function "Field reversal" is not possible with the DI-channel.

9.6.2. DI-channel selection

The acknowledge-signal is selected by the same parameter that is used to select a field exciter type

FEXC_SEL (11-10)

...	
5	acknowledge through DI4
6	acknowledge through DI6
7	acknowledge through DI7
8	acknowledge through DI8
...	

9.6.3. Use of AI-channel

Analogue input is used when field current is wanted to measure or control. When controlling AI-based field exciter, it is also needed to transfer reference to the field exciter. This can be done by means of connecting one AO channel to the signal

FIELD1_CUR_REF (103-18).

The scaling of the used AO must be arranged so that the value 4096 correspond with the input voltage value of the field exciter current reference input. The field current actual signal must also scale so that the scaled input value = 4096 with the rated field current.

9.6.4. AI-channel selection

The selection for acknowledge-signal is selected by the same parameter that is used to select a field exciter type

FEXC_SEL(11-10)

...	
9	acknowledge through AITAC
10	acknowledge through AI1
11	acknowledge through AI2
12	acknowledge through AI3
13	acknowledge through AI4

9.7. Two field exciters at a same time

When the same converter controls two motors as a "shared motion" the armature unit is switched between two motors by means of extra contactor. Both motors have still their own field exciters. In the documents the main motor field exciter is called "first field exciter" and second motor as "second field exciter".

Only "first field exciter" can be current controlled. "Second field exciter" use always fixed field current level.

Motor heating function is possible for the not used motor by means of giving small field current reference to the field exciter.

9.8. Settings

For the program the nominal field current *must be given* in order to have correctly controlled field. Overcurrent and minimum level are not normally needed to change.

The nominal current of field exciters

I_MOT1_FIELDN_A (13-03)	100 = 1 A
I_MOT2_FIELDN_A (13-17)	

The minimum field current level

FIELD1_CUR_GT_MIN_L (8-17)	4095 = rated current
FIELD2_CUR_GT_MIN_L (8-22)	2047 = 50% of rated

The overcurrent level

FIELD1_OVERCUR_LEV(12-11)	4095 = rated current
FIELD2_OVERCUR_LEV(12-12)	4710 = 115% of rated

9.9. Free-wheeling function

DCF504 has a free-wheeling function in order to give route to current if for some reason the AC-input voltage disappears, e.g. when field contactor opens in an uncontrolled way. When this happens, the current does not stop and current tends very rapidly to increase the line voltage input of the field excitation unit. The AC input voltage is measured and if the value changes too fast, the field excitation unit fires two selected thyristors in order to kill current fast. The sensitivity when to start the free-wheeling can be adjusted by means of next parameters

FEXC1_U_AC_DIFF_MAX (8-04) Scaling of parameters are unit/ms
FEXC2_U_AC_DIFF_MAX (8-10)

Field exciters internal voltage scale:

500 VAC (rms) =	3.277 V
763 VAC =	5.0 V
1023 =	5.0V (A/D conversion)

The default value is 10. This means that the free-wheeling starts if AC-input voltage measurement increases more than 7.6V/ms.

9.10. Filter for actual field current

The field exciter unit has a filter for smoothing the actual field current measurement transferred to the drive software. The filter is meant for smoothen actual current measurement value for displays.
The filter time constant should not be increased too much because the same signal is also used for supervising overcurrent of the field overcurrent.

FEXC1_CUR_TC (8-01) Scaling: 1 = 0.01 sec.
FEXC2_CUR_TC (8-07)

9.11. Current controller

The current controller of the field excitation unit is located inside the field excitation unit. Some parameters are accessible via serial communication link if the current controller needs manual tuning. The current controller is normal PI-control that has one parameter for P-gain and second parameter for I-time constant.

P-gain parameters:

FEXC1_KP (8-02) Scale: 1 = 100%
FEXC2_KP (8-07)

PI-controllers input value quality is current and output value quality is voltage.

I-time constant parameters:

FEXC1_KI (8-03)	Scale: 1 = 10 ms
FEXC2_KI (8-09)	

The maximum output voltage of the PI-controller can be limited by means of 2 parameters. When the bridge is full open the output voltage is 0.9 * VAC. This equals the limit value 4095. The limitation is linear so 2048 = 0.5 * 0.9 * VAC.

FEXC1_U_LIM_N (8-05)	negative limit
FEXC2_U_LIM_P (8-06)	positive limit
FEXC1_U_LIM_N (8-11)	negative limit
FEXC2_U_LIM_P (8-12)	positive limit

9.12. Changing of field direction

Changing of field direction is needed when the drive has only one armature bridge (1-quadrant). This gives the possibility to change a speed direction and also regenerating energy back to network when decelerating a speed down with a heavy inertia. The sign of the Torque reference defines the wanted direction of the field. 4-Quadrant equipped drive does not have the field direction changing facilities.

The field direction change can be activated by means of parameter

FIELD1_MODE(11-11)

0	no EMF-control	4-quadrant
1	EMF-control	-"-
2	**Field reversal**	1-quadrant
3	**Field rev.** + EMF-control	-"-
4	**Field rev.** + OPTITORQUE	-"-
5	**Field rev.** + OPTITORQUE + EMF-control	-"-

When using 4-quadrant-type drive the field reference value is always positive 100% (unit value 4095). If EMF-controller is activated, then field current is controlled but still it can never be bigger than 100%.

9.12.1. Field direction change hysteresis

To avoid too sensitive function when the torque reference value is small one parameter is needed to form hysteresis around zero torque reference. The hysteresis is symmetrical against zero. The hysteresis value is set by the parameter

FIELD1_REF_HYST	Scale: Field current unit
(8-19)	4095 = nominal.

9.12.2. Force field direction

It is possible to force drive to use a defined field direction. This gives the possibility to user to allow the direction change only when it is needed. Using the force-command makes the drive less sensitive to the torque reference. Two signals are defined for forcing the field direction:

FORCE_FIELD1_FWD **(108-04)**	0 = no force <>0= force FWD field
FORCE_FIELD1_REV **(108-05)**	0 = no force <>0 = force REV field

9.12.3. Field monitoring when changing direction

Normally field current is compared to minimum level and if current falls below the minimum limit, all control functions are blocked and the drive goes to the state **RDYRUN** = 0 and **RDYREF** = 0. During the field change the situation differs. It is allowed to be under the minimum field level certain time because the field current must pass over the zero current. In the process of field changing the current controller is blocked , speed controller I-part is frozen and speed ramp output is updated by the measured speed value.
The field current must change the direction in a period of 2 sec, otherwise signal **ACK_FEXC1_ON** goes to 0. This causes the situation **RDYRUN** = 0 and **RDYREF** = 0.
In order to supervise the function next parameters are needed:

FIELD1_CUR_GT_MIN_L **(8-17)**	the minimum level for the the field current. Scale: 4095 = nominal.
FIELD1_REV_HYST **(8-18)**	The sign of the field current defines used direction. To avoid signal noise problems, a small hysteresis is used when measuring the sign. Scale: 4095 = nominal.
FLUX_TD **(8-16)**	If real FLUX of the motor does not follow rapidly the field current, (old DC-motors), it could be necessary to make extra delay for defining field direction. Normally this time can be 0.

Next signals are needed for controllers and some measurements:

TC_FIELD_CHANGE (110-06)	During field reversal this signal blocks armature current controller, freeze I-part of the speed controller and update speed ramp output with a measured speed value.
FIELD1_REV_ACK (108-14)	When the direction is changed to the reverse direction, the polarity of next signals must be changed: **SPEED_ACT_EMF**,**TORQUE_ACT**, armature current reference.

9.13. OPTI-Torque

The time needed normally to change field direction is quite long because of the big inductance of the motor. This time can be reduced in certain cases by means of using OPTI-TORQUE-facilities. If the nature of the process behaves so that during field reversal also only a small torque is needed, then it is possible to reduce the field current before the real change is activated. This technique fastens the procedure. How much the field current can be reduced depends on the process. E.g. if the speed direction is changed rather slowly, then the torque needed can also be quite small near the zero speed and for this reason the motor field can also be reduced.

9.13.1. Selection of OPTI-torque

The OPTI-TORQUE can be selected by parameter:

FIELD1_MODE (11-11)

0	no EMF-control	4-quadrant
1	EMF-control	-"-
2	Field reversal	1-quadrant
3	Field rev. + EMF-control	-"-
4	Field rev. + **OPTITORQUE**	-"-
5	Field rev. + **OPTITORQUE** + EMF-control	-"-

9.13.2. Field current reduction proportionally to torque ref.

The relationship between torque reference and field current is defined by parameter

FIELD1_REF_GAIN (8 20)

Scaling is per cent (%). The value 100 means that field current is directly proportional to torque reference. When it is wanted that 10% torque reference can produce full field current, then the gain value is set to 1000.

9.13.3. Field monitoring when OPTI-torque changes field direction

Field monitoring differs from normal field changes that during field reversal other controllers are not blocked. The signal **TCFIELDCHANGE 110-06** is clamped to zero. Minimum field signal is normally delayed by 2 seconds and this time is fixed. Because the time how long the field current stays under the minimum level is also a function of torque reference and torque reference depends on process and speed controllers gain-values, this 2 second can be too short time for some application.
For this reason the minimum field monitoring is by-passed if field ***current reference*** goes under certain level. Two parameters are needed for declaring the threshold to the reference when minimum level is by-passed.

FIELD1_REF_MIN_L (8-14)	**614 = 15% of nominal** When field reference falls below this limit the minimum field monitoring is by-passed.
FIELD1_REF_MIN_TD (8-15)	Extra delay to keep by-passing activated after the field current is again aroused above reference level.

9.14. Field current / motor FLUX linearization

When it is needed to control accurate torque, e.g. winders uncoilers, the field current must be linearised. The reason is that torque = motor armature current multiplied by motor FLUX but motor FLUX is not directly proportional to field current.

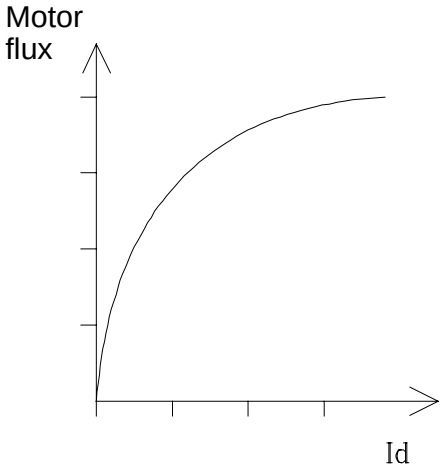


Figure 20 Flux of DC-motor in function of the field current.

The magnetisation of the motor starts to saturate after certain field current and thus the motor flux does not increase linearly. For this reason the field current cannot be directly used to define FLUX inside the motor. On the other hand the motor armature voltage without load (=EMF) is directly proportional to the motor flux and motor speed below field weakening area. E.g. if motor nominal

DC voltage is 440V and the motor is run using half speed and full FLUX, then the DC voltage is about 220V. Then if the flux is reduced by 50% and while keeping the same speed, the DC voltage is about 110V. (Only an example!).

Because the motor EMF-voltage is directly proportional to motor FLUX it is possible to define relationship between field current and motor FLUX by means of measuring motor armature voltage without load (EMF).

The main idea for linearisation is to find such field current which produces desired EMF-voltage at a certain speed. The linearisation is done using a Function block that needs 3 defined values, 90% flux field current, 70% and 40%. Rest of the values are interpolated. During commissioning the values for the function block must be defined when EMF-controller is meant to use.

Only EMF-controller use the linearisation function.

9.14.1. An example of the linearisation procedure

There are many ways to define needed values for the function block. Next procedure is presented to clarify linearisation.

1. Select **FIELD1_MODE(11-11) = 1**
Set EMF-controllers P- and I- parameters to zero
Set **EXT_FLUX_REF_SEL(10-07)** = 1
Set **FLUX_REF (108-01)** = 4095

2. Run the motor to half speed.
Read **EMF_V(118-07)** e.g. measured value is 220V

3. Reduce **FLUX_REF** as long as **EMF_V** reach the value 0.9 * 220V
Read the value **FIELD1_CUR_ACT (118-10)** and write that value into parameter **FIELD1_CONST1 (13-14)**

4. Reduce again **FLUX_REF** until **EMF_V** reach the value 0.7 * 220V
Read the value **FIELD1_CUR_ACT(118 10)** and write that value into parameter **FIELD1_CONST2(13-15)**

5. Reduce again **FLUX_REF** until **EMF_V** reach the value 0.4 * 220V
Read the value **FIELD1_CUR_ACT(118-10)** and write that value into parameter **FIELD1_CONST3(13-16)**

After values are defined the EMF-controller is able to control motor FLUX and thus the motor torque can also be controlled into desired level.

9.15. Field reduction when stand-still

The motor field can be reduced at a stand-still situation in order to avoid overheating when motor is not running. The function can be activated by means of two parameters:

FIELD1_RED_SEL (11-18)	Selection for first motor
FIELD2_RED_SEL (11-19)	Selection for second motor in case of shared motion.

The used current reference can be selected by means of two parameters:

FIELD1_REF_RED (8-13)	Reference for first motor
FIELD2_REF_RED (8-21)	Reference for second motor in case of shared motion.

The function is activated when

- "**ON**"-command is "1", so the main contactor is closed
- the drive is in **RDYREF** -state.
- 10 second is elapsed.

9.16. Field heating when "OFF" -state

The motor field can have a small value in order to avoid condensation when motor is in "**OFF**"-state. The function can be activated by means of parameter:

FIELD_HEAT_SEL (11-17)

The used current reference are the same as with the field reduction function:

FIELD1_REF_RED (8-13)	reference for first motor
FIELD2_REF_RED (8-21)	reference for second motor in case of shared motion.

The function is activated when command "**ON**" is "0", so the main contactor is open. The function closes the field contactor.

10. EMF -CONTROLLER

The EMF - controller has two main control functions:

When running the motor above base speed , the EMF-controller reduces motor field on purpose of maintains the EMF-voltage constant at a maximum level. This must be done to avoid armature over voltage and on the other hand maximum EMF is needed to hold FLUX as high as possible.

When an accurate torque controller loop is needed, the EMF - controller can be used to form wanted FLUX. The APC-application program can calculate what the value of the motor EMF ought to be with used speed and used FLUX reference. The EMF-controller adjust then field current so that the measured EMF correspond with a wanted EMF-reference.

10.1. Selection of EMF - controller

The EMF-control function can be activated by means of parameter **FIELD1_MODE(11-11)**

0 No EMF-control (constant field) without field reversal
1 **EMF-control** without field reversal
2 No EMF-control (constant field) with field reversal
3 **EMF-control** with field reversal
4 OPTITORQUE without EMF-control
5 OPTITORQUE with **EMF-control**

Field reversal is normally meant for 1-quadrant drive type. The type of the field exciter must also be such that field current can be controlled like SDCS-FEX-2, DCF503/504.

10.2. Field weakening area

Above certain speed the motor FLUX must be reduced in order to avoid armature over voltage. This area is called "field weakening area" and the speed point where the field reduction starts is called "field weakening point". Above field weakening point the motor FLUX is reduced by ratio 1/n. Two parameters are needed to carry out the function:

SPEED_SCALING (13-18)	Max. speed of drive in 0.1 rpm. This rpm value equals to unit value 20000.
FIELD_WEAK_POINT (13-13)	The motor field weakening point. Scaling in speed units.

10.3. FLUX reference

The FLUX reference can be internally calculated or APC can give reference when there is some special demands from the process point of view.

The controlling area for FLUX is 1:5 so the minimum FLUX reference is 20% of the motor nominal. In case of EMERGENCY STOP the reduced FLUX reference is changed to maximum possible FLUX reference defined by field weakening area.

It is not possible to have bigger reference value than 100% of the motor nominal, FLUX unit 4095.

APC can command the FLUX reference by means of signal

FLUX_REF (108-01) Scale: 20% equal to 819
100% equal to 4095

10.4. EMF reference

The EMF reference can have an internally defined fixed level or the EMF reference given by APC. Internally defined fixed level is used when EMF-controller is only limiting the armature voltage above the field weakening point. The level is given by the parameter

$$\textbf{LOCAL_EMF_REF (13-19)} = \frac{3786 \times \text{EMF ref. voltage}}{1.35 * \text{U_SUPPLY}}$$

The initial value is 2964 so EMF-controller starts to reduce FLUX-reference when measured EMF reaches the level 78% of max. possible EMF.

APC can also be used to define EMF-reference. This is used when most accurate torque controller loop is needed. In this case APC has such a program that EMF-reference follows the speed actual of the drive.
The level for EMF reference is given by signal

$$\textbf{EMF_REF (108-03)} = \frac{3786 \times \text{EMF ref. voltage}}{1.35 * \text{U_SUPPLY}}$$

10.5. FLUX/EMF reference selectors

There are two ways to select between internal and external FLUX and EMF reference. Either selecting them separately by means of parameters or together by means of one signal.

When selecting FLUX and/or EMF reference separately, only **EMERGENCY STOP** can by-pass the selection so that always max. possible FLUX is used. The selection can be done by the parameters:

EXT_FLUX_REF_SEL (10-07)
EXT_EMF_REF_SEL (10-08)

APC can command both references ON/OFF by means of signal

EXT_EMF_FLUX_SEL (108-02)

This is useful e.g. when web break occurs. By selecting "OFF" the EMF-controller starts immediately use max. possible FLUX so the function is similar than the EMERGENCY STOP function.

10.6. PI - controller

PI-controller corrects inaccuracies caused by process, e.g. network AC voltage variations.
I-part of the controller is reset below certain EMF-level because the rotor resistance value I_R would otherwise cause an erroneous result.
The limit when I-part is released can be defined by parameter:

EMF_REL_REF(10-05)	default value is 50 (100 * 50/3786 = 1.3%)

10.6.1. Scaling of PI

P-gain of the controller is reduced above field weakening point by the factor 1/n in order to keep process gain constant. P-gain can be adjusted by means of parameter

EMF_KP (10-03)	Scaling is internal unit 277 = 100 % 150 = 0.54 (54%)

I-time constant does not have 1/n scaling factor and it is separated from P-gain value. I-time constant can be adjusted by means of parameter

EMF_KI (10-04)	Scaling is internal unit 44600 = 3.3 ms 4905 = 30 ms

10.6.2. PI-controller output limitation

The output of the PI-controller is limited so that 100% of final FLUX reference is absolute maximum. The positive level of PI-controller is limited so that exactly at a field weakening point the positive limit is zero. Above the field weakening point the positive limit starts to increase in order to make possible a smooth transfer to the field weakening area.

When **LOCAL_EMF_REF** is used then PI-controller stays on a positive limit on the constant field area. That is because reference is fixed (2964) and measured **EMF** is much lower.

Limits for the PI-controller can be adjusted by means of parameters

EMF_REG_LIM_P (10-01)	4095 = nominal FLUX +410 = +10%
EMF_REG_LIM_N (10-02)	-4095 = -nominal FLUX

10.7. Force to max. possible field

In case of **EMERCENGY STOP** maximum possible field is forced to the FLUX reference despite of other controller references.

Forcing can also be done using the signal **EXT_EMF_FLUX_SEL (108-02).**

11. ANALOG AND DIGITAL I/O

11.1. Digital inputs

The digital inputs consist of **eight** (8) connections. All the connections are on the **SDCS-IOB-2** board. The digital inputs are isolated and filtered. The time constant for filters can be selected. Input voltage levels are 24 V dc...48 V dc, 115 V ac or 230 V ac depending on the hardware of the board. Inputs **DI1, DI2, DI3** (and **DI5**) are dedicated to the **internal use only**, like acknowledge of main contactor.
The program reads fast (3.3 ms) channels DI7 and DI8.
Digital inputs DI4 and DI6-DI8 are programmable and they can be used in several purposes, like:

the acknowledge of external field exciter
disable local-mode
disable ON-command
block the drive
motor temperature protection(Klixon)
application program of the APC.

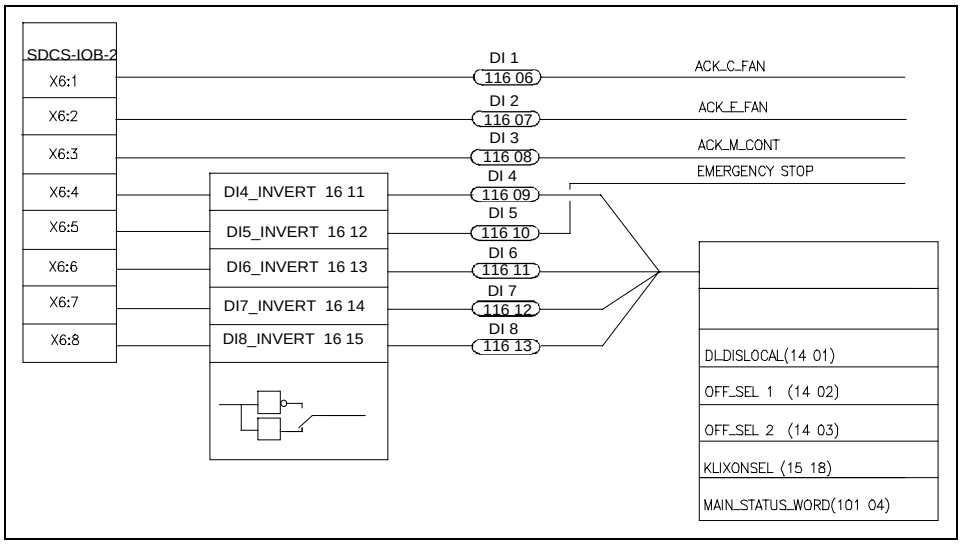


Figure 21 Digital inputs of DCV 700 and purposes of them.

11.1.1. Fixed digital inputs

The control logic of the program uses fixed digital inputs **ACK_C_FAN**, **ACK_E_FAN**, and **ACK_M_CONT** for supervision that given commands are executed.

11.2. Digital outputs

Digital outputs consist of **eight** (8) connections. All the connections are on the **SDCS-IOB-2**- board. The outputs of the board are isolated, two of them with optocouplers and the rest with relays. First three outputs **DO1, DO2, DO3** are dedicated to the **internal use only**, e.g. control of the main contactor. Digital outputs **DO4-8** are programmable.

Connections of the digital output are made by means of parameters

DO4_IND (17-08)
DO5_IND (17-10)
DO6_IND (17-12)
DO7_IND (17-14)
DO8_IND (17-16)

Any boolean information of the program can be connected to the DOs, e.g. **RUN1(114-01)**, **ZEROSPEED(114-05)**, **FAULT(114-05)**.

APC can also command the digital outputs. In this case the parameter DOx_IND is set to zero. When zero, the program reads the command from the **MAIN_ CONTROL_WORD (101-01)** and/or **AUX_CONTROL_WORD (101-02)**.

Digital outputs can also be inverted by parameter(s)

DO4_INVERT (17-07)
DO5_INVERT (17-09)
DO6_INVERT (17-11)
DO7_INVERT (17-13)
DO8_INVERT (17-15)

scale: 1==invert.

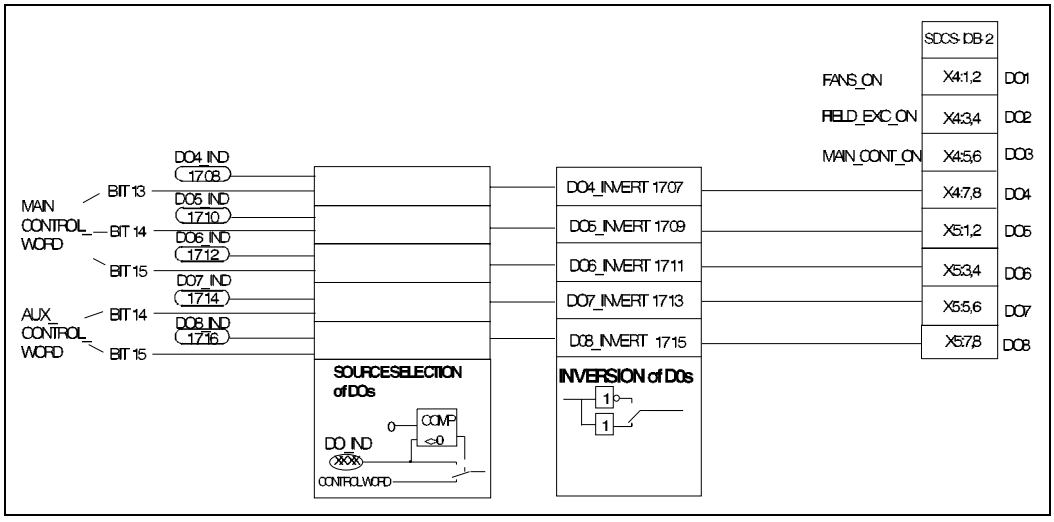


Figure 22 Principle of the digital outputs.

11.3. Analogue inputs

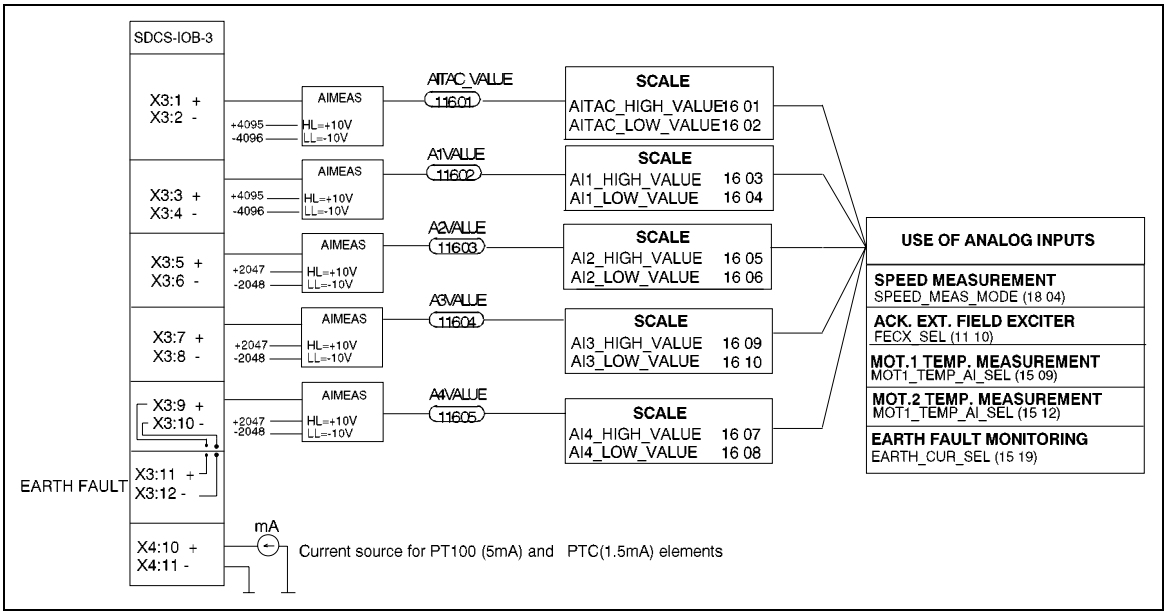


Figure 23 Basics of DCV 700's analogue inputs.

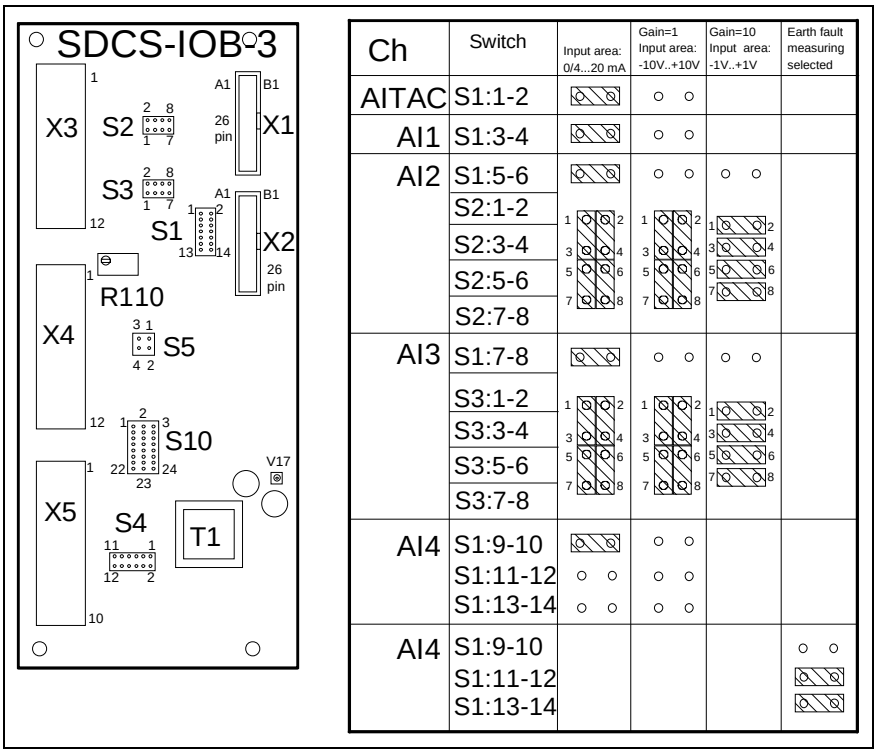
Analogue inputs consist of **five** (5) channels. All connections are on the **SDCS-IOB-3** board. All channels are programmable and can be scaled when needed for the applications. Resolution of channels 1...2 is 12 bits +sign and channels 3...5 11 bits +sign.

SDCS-IOB-3:

- input range: -10 V...+10 V, 0/4 mA...20 mA, -1 V...+1 V (ch. 3 and ch. 4)
- The input range is selected by jumpers of the board, see figure below
- all analogue inputs are galvanically isolated
- current generator for PT100 (5 mA) and PTC (1,5 mA) elements
- Earth fault monitor input

Analogue inputs can be used for following internal applications:

- acknowledge external field exciter FECX_SEL(11 10)= 9..13
- speed measurement SPEED_MEAS_MODE(18 06)
- temperature measurement(s) of the motor(s)
- Earth fault monitoring



Ch	Switch	Input area: 0/4...20 mA	Gain=1 Input area: -10V..+10V	Gain=10 Input area: -1V..+1V	Earth fault measuring selected
AITAC	S1:1-2				
AI1	S1:3-4				
AI2	S1:5-6				
	S2:1-2				
	S2:3-4				
	S2:5-6				
	S2:7-8				
AI3	S1:7-8				
	S3:1-2				
	S3:3-4				
	S3:5-6				
	S3:7-8				
AI4	S1:9-10				
	S1:11-12				
	S1:13-14				
AI4	S1:9-10				
	S1:11-12				
	S1:13-14				

Figure 24 The jumpers coding of the analogue inputs.

Current generator settings for the PT100 and PTC elements are following:

S5: 1-2 closed **S5**:3-4 open 1,5 mA (PTC)
S5: 1-2 open **S5**:3-4 closed 5 mA (PT100)

11.4. Analogue outputs

The analogue outputs consist of **three** (3) channels. All connections are in the **SDCS-IOB-3**-board. First two outputs are programmable. The range of outputs is +10V...-10V and the resolution are 11 bits + sign.

The third output is fixed and used for indication of armature actual current directly from HW measurement. The basic scale of the output: 3V equal to converter nominal current.
The gain can be adjusted by means of potentiometer R110 in the SDCS-IOB-3 board.

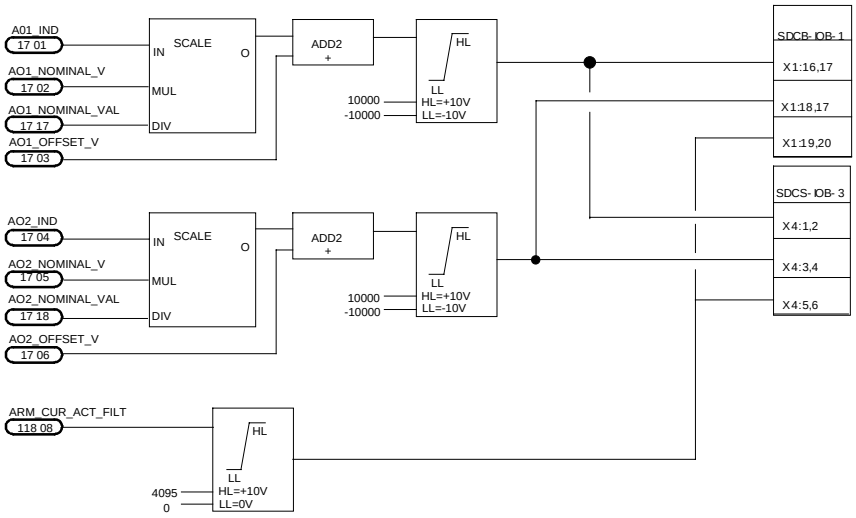


Figure 25 Basics of the analogue outputs.

The signal selections for analogue outputs are made by the parameters

AO1_IND (17-01) 0 = APC commands the channel
AO2_IND (17-04) <> 0 = signal number

The output is scaled by the parameters

AO1_NOMINAL_V (17-02) Output V in mV when measured signal equal to the value given by parameter 17 17.
AO1_NOMINAL_VAL (17-17) The nominal value of the measured signal.
AO2_NOMINAL_V (17-05)
AO2_NOMINAL_VAL (17-18).

Certain offset voltage can be given by the parameters

AO1_OFFSET_V (17-03) Scale: mV.
AO2_OFFSET_V (17-06)

12. ELECTRICAL DISCONNECTION

The start sequence can be prevented by digital inputs. This is normally used during maintenance of the motor. The function of the current controller is also prevented.

APC can monitor the status of the electrical disconnection by reading bit **INH.OF F.START** (15) from the **MAIN_STATUS_WORD (101-04)**.

DI4 is selected to control the OFF1 as a default.

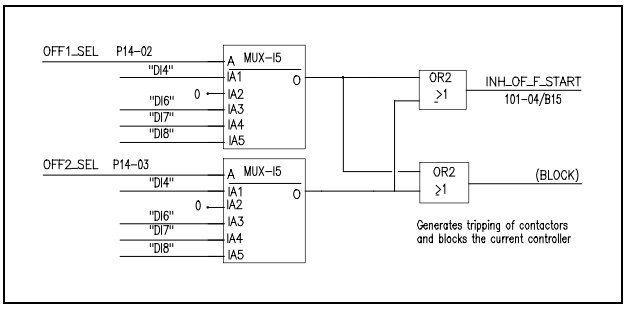


Figure 26 The selections of the electrical disconnection.

The selections of the OFF-commands are made by the parameters:

OFF1_SEL (14-02): 1 = DI4 disable the ON command,(default value)
OFF2_SEL (14-03): 0 = not used (default value)

13. DC-BREAKER

The DC-breaker is used to protect the motor from overcurrent or ***if*** in case of mains under voltage the generator bridge is shooting through.

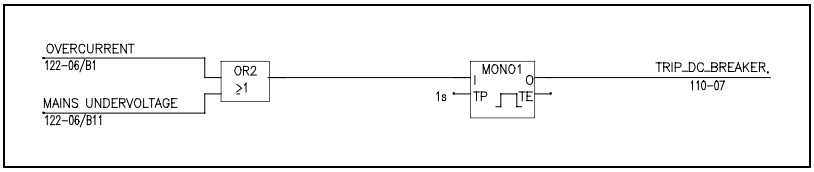


Figure 27 The control of a DC-breaker.

The program produces the signal **TRIP_DC_BREAKER (117-07)** immediately after overcurrent or mains under voltage is detected. When connecting some DO-channel to follow this signal, in that special case the DO-channel is updated as fast as possible (immediately after detecting the tripping situation).

14. DYNAMIC BRAKING

In cases of emergency stop or a communication break of the TC-link the drive can be stopped by using the function ***dynamic braking*** in order to transfer the power of the machine inertia into the braking resistor.

The function opens the main contactor but keeps the field "ON". After the acknowledge signal of the main contactor is "OFF", the function produces the signal which can be used to connect breaking resistors in parallel to the armature circuit.

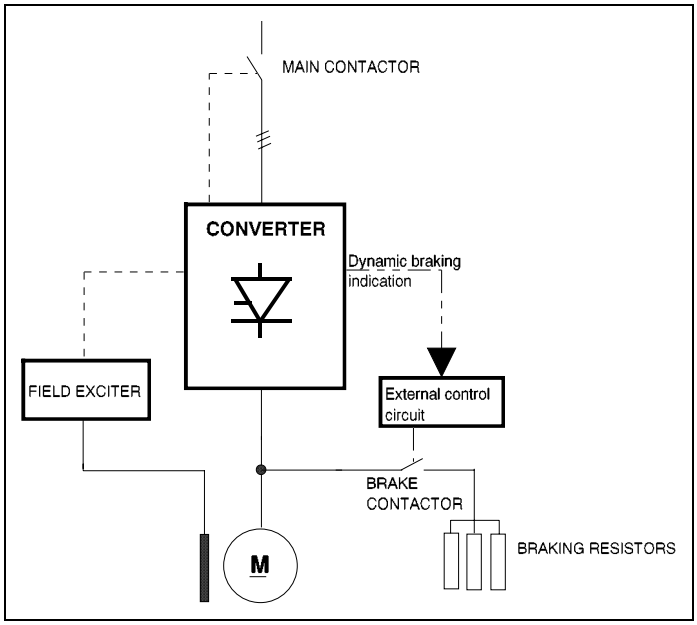


Figure 28 The application example of the dynamic breaking.

One channel of DOs is connected to the signal

DYN_BRAKE_ON (110-08)

APC must keep the ON-command active during breaking. Otherwise the field contactor will open.

The function is activated by the parameters:

APC_COM_BREAKRESP (19-02)
4 = use dynamic braking in case of APC time-out

EMESTOPMODE (11-05)
3 = use dynamic braking in case of emergency stop

15. SHARED MOTION

When the same converter controls two motors the connections for motors are made with external contactors. Both motors have still their own field exciters. The field exciter called "first field exciter" can be controlled normally. Another field exciter for the motor 2 is controlled only by using constant field current reference. This function is used e.g. in the crane application where one motor is used for lift the load with adjustable field and the other motor is used e.g. moving the whole crane. Only one motor is driven simultaneously.

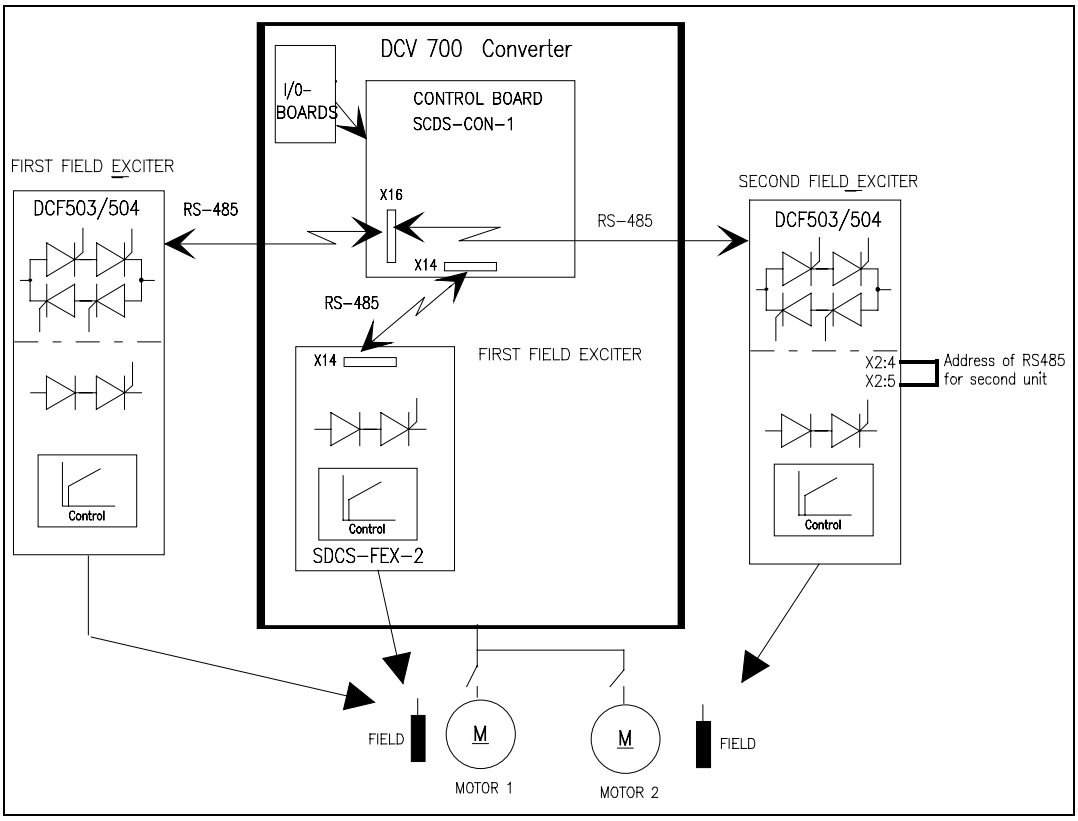


Figure 29 Principle of the shared motion.

The type of the first field exciter can be either SDCS-FEX-2 or DCF503/504. The second unit must be DCF503/504. For second unit the address of the RS485 serial link is set by the hardware jumper in the DCF503/504 terminal blocks.

The control program of the converter includes parameters and signals for both field exciters.

If type of the motors or settings of controllers for motors are different the changes of these parameters must be handled by means of APC application program.

16. POWER LOSS MONITORING AND AUTO-RECLOSING

The Auto-Reclosing function allows to continue drive operation immediately after a short network failure without any complicated APC- application program logic.

In order to keep APC and drive control electronics running through the short network dip, a UPS is always needed for 220 V AC auxiliary voltage. Without the UPS all DI-signals like emergency stop, faulty start inhibition (OFFx), acknowledge signals etc. would have false states although the system itself would stay alive.

The Auto-Reclosing function defines whether the drive is tripped immediately by net under-voltage or the drive will continue running after the net voltage returns.

16.1. Function during a short network failure

The supervision of main supply under voltage has two limits,

U_NET_MIN1 (9-01) for the alarm level and
U_NET_MIN2 (9-02) for tripping level.

When network voltage falls below the **U_NET_MIN1 (9-01)** limit but stays above the **U_NET_MIN2 (9-02)** limit, the drive will make next actions:

Firing angle is set to max.
Half pulses are taken into use in order to kill current as fast as possible
For APC/CMT: alarm "**Mains underv alarm**" -**118-** is generated.
During net failure a measured **SPEED_ACT (104-05)** is updated to the speed ramp output.
the output of the EMF-controller is frozen.

If network voltage returns before the time defined by parameter **PWR_DOWN_TIME (9-03)** and APC keeps commands "ON" and "RUN" = 1, the drive will start. After the start next text is written to the fault logger

"**Auto-reclosing**" **-130-**

When network voltage falls below the limit **U_NET_MIN2 (9-02)** , the action can be selected by means of parameter

PWRLOSS_CONTROLMODE (11-08)

0= the drive will trip immediately to the fault 30: "**mains undervoltage**".
1= The drive starts automatically if possible. Below the limit **U_NET_MIN2** the field acknowledge signals are ignored.

If UPS is not available, then the limit **U_NET_MIN2 (9-02)** *should be selected so that the drive will trip to the main under voltage fault instead of some secondary phenomenon because of missing power for DIs or AIs.*

16.2. MAIN_STATUS_WORD during net failure

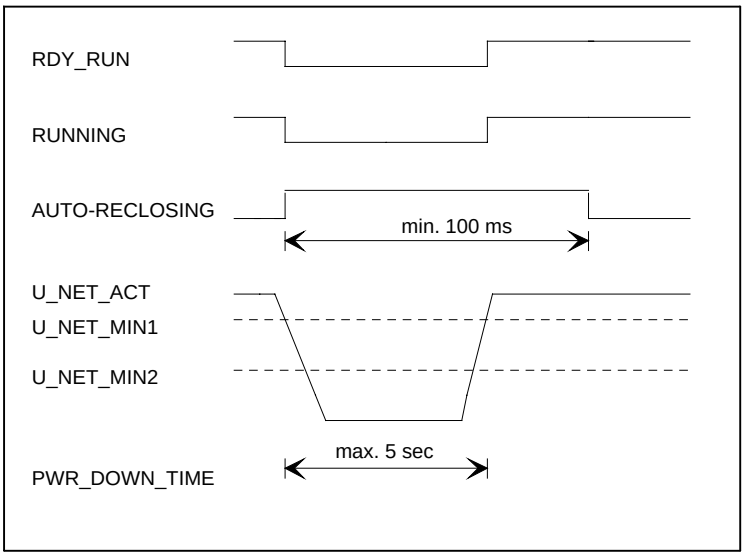


Figure 30 Auto-reclosing control signals.

16.3. When aux. supply voltage fails

If 220 V AC auxiliary supply voltage fails during run, to the fault logger is written the text:

"**Auxil. undervoltage**" **-1-**

When 220 V AC drops during stand-still, to the fault logger is written the text:

"**Aux. underv.alarm**" **-132-**

17. EARTH FAULT MONITORING

The earth fault indication is based on a sum current transformer T1 in the AC-side of the converter. The secondary side is connected to the analogue input channel AI4 of the SDCS-IOB-3-board. The sum current of three phases has to be zero, otherwise there must be earth fault. The earth fault protection is activated by means of the parameter:

EARTH_CUR_SEL (15-19)

0 = not used (default value)
1 = activated

Earth fault current tripping level is set in Amps to the parameter:

EARTH_FAULT_L (15-20)

4 = default = 4A

The delay before tripping is set in 0.001 s to the parameter:

EARTH_FAULT_DELAY (15-21),

10 = default = 10 ms

18. POSITION COUNTER

Position counter is used for position measurement in DCV 700 drive applications. The counter can be synchronised (=preset with SYNC-values) by the APC application software or by the hardware. Counter output and SYNC-values are 32-bit signed values.

32-bit position values are sent to the APC / received from the APC as two 16-bit values. APC has a special FB for connecting two 16-bit values to one 32-bit value and vice versa.

18.1. Counting procedure

Position counting is executed at 3.3 ms time intervals with 32-bit up/down counter.
Tacho pulses can be monitored from the signal **TACHO_PULSES (123-04)**.
Counting is upwards when the motor is rotating forward and downwards when the motor is rotating backward.
The measurement mode of tacho pulses is selected with the parameter **SPEED_MEAS_MODE (18-04)**.

18.2. Synchronisation

At the synchronisation the position counter is initialised by the defined value

POS_COUNT_SYNC_LOW (105-01) **POS_COUNT_LOW (105-03)**
POS_COUNT_SYNC_HIGH (105-02) **POS_COUNT_HIGH (105-04)**

At the same time the bit **SYNC_RDY** (8) in the **MAIN_STATUS_WORD (101-04)** is set to 1.

Synchronisation can be inhibited by setting bit **SYNC_DISABLE** (6) at **MAIN_CONTROL_WORD (101-01)** to 1.

Synchronisation can be inhibited by setting bit **SYNC_DISABLE** (6) at **MAIN_CONTROL_WORD (101-01)** to 1.

18.3. Selection of synchronisation input

The synchronising source is selected with the parameter

SYNC_INPUT (5-01).

0 = Not in use

1 = **DI7hi**
digital input 7 rising edge (low to high edge sensitive)

2 = **DI7hiZS**
DI7hi+Zero channel pulse from encoder, DI7 at high-state.

3 = **DI7hiZSpos**
DI7hiZs + motor rotating forward.

4 = **DI7hiZSneg**
DI7hiZs + motor rotating backward.

5 = **DI7lo**
digital input 7 falling edge (high to low edge sensitive).

6 = **DI7loZS**
DI7hi+Zero channel pulse from encoder, DI7 at low-state.

7 = **DI7loZSpos**
DI7loZs + motor rotating forward.

8 = **DI7loZSneg**
DI7hiZs + motor rotating backward.

9 = **Zero Strobe**
Zero channel pulse.

10= **APC**
MAIN_CONTROL_WORD (101-01) bit 5 rising edge

18.4. Calculation

At every execution time the actual position POS_COUNT is calculated using the formula:

DELTA_TACHOPULSES = **TACHOPULSES**(new) - **TACHOPULSES**(old) .
POS_COUNT(new) = **POS_COUNT**(old) + **DELTA_TACHOPULSES**

Fastest synchronisation is achieved with encoder zero pulse synchronisation, because it is hardware based. Digital input DI7 synchronisation is software based. (DI7 is read on 3.3 ms intervals).
Additional delay comes from the HW-filtering time 2 ms...10 ms of DI7 (depending on the settings of the terminal board SDCS-IOB-2).

18.5. Position counter diagram

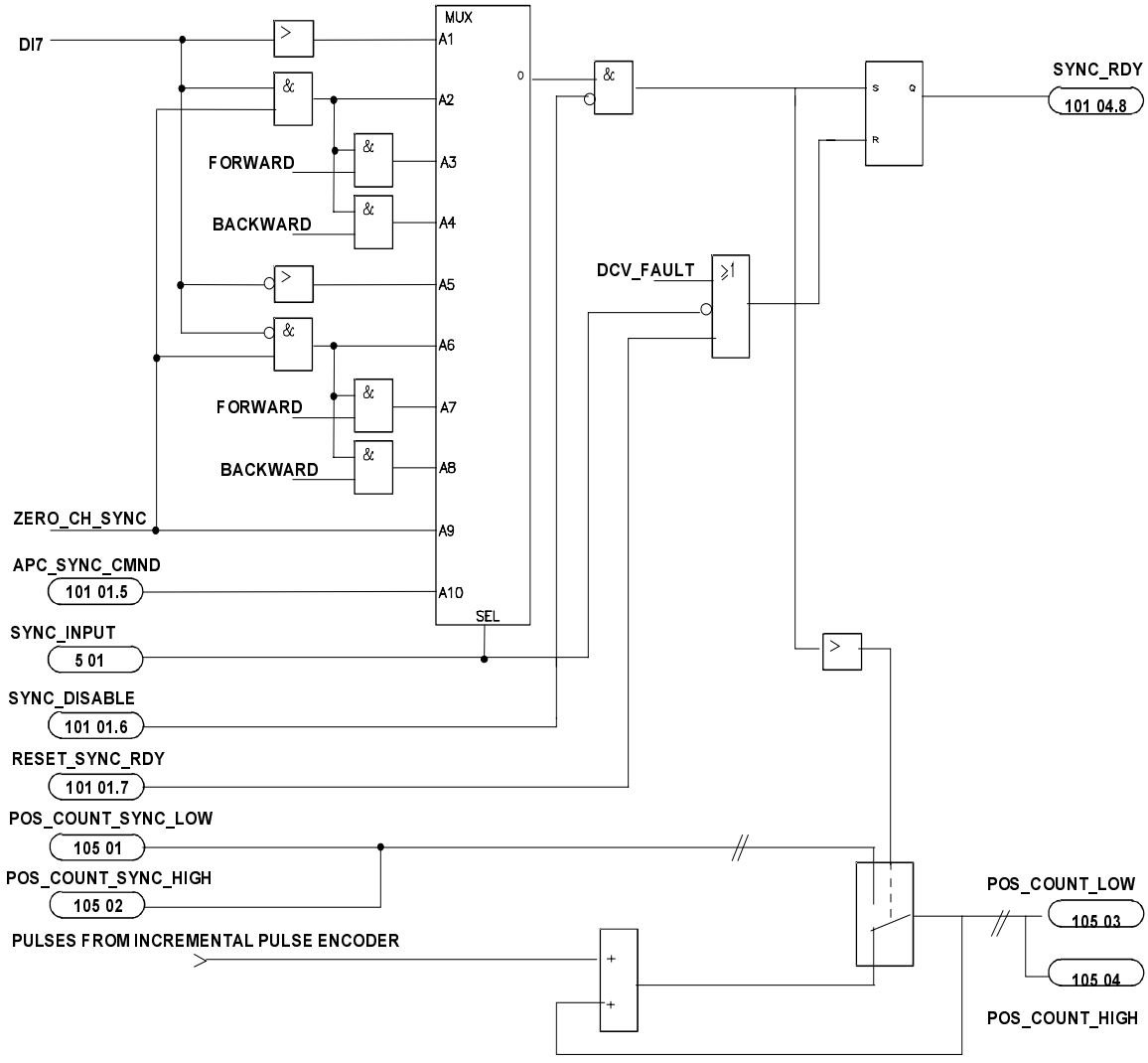


Figure 31 Position counter logic.

19. MONITORING FUNCTIONS

19.1. Speed measurement supervision

The supervision of the speed measurement is based on the relation between the measured speed and measured/calculated EMF.

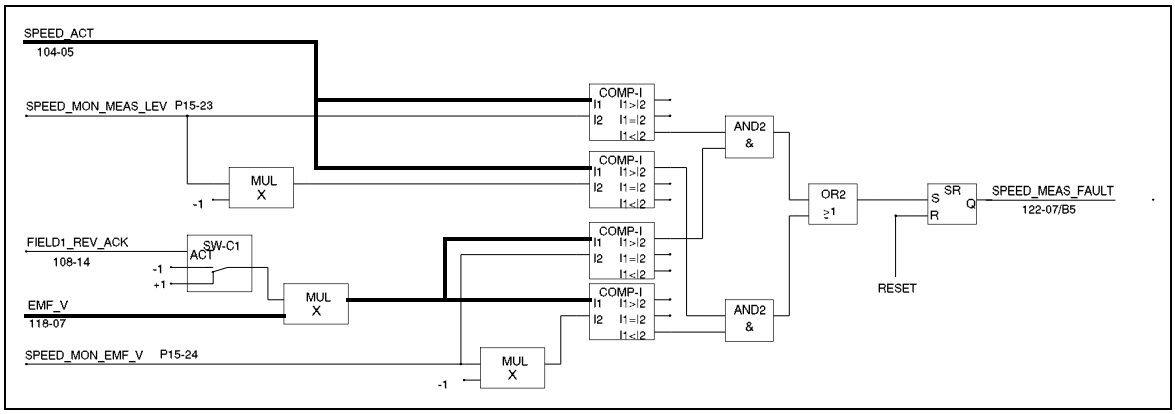


Figure 32 The speed measurement supervision.

Above certain EMF-voltage the measured speed must also be above zero and the sign of the speed measurement must be correct. Otherwise the **"SPEED_MEAS_FAULT" -14-** will be generated.
The level of EMF-voltage when the supervision is activated is set by parameter

SPEED_MON_EMF_V **(15-24)** default: 50V

How much the speed must at least be is set by the parameter

SPEED_MON_MEAS_LEV **(15-23)**. default: 200 (1%)

19.2. Network phase sequence

The direction of network phases is checked when the main contactor is closed. The measured direction must correspond to the value given by parameter

PHASE_SEQ_CW (18 01):

1= R-T-S
2= R-S-T, default set.

If the measurement mismatch, the "**PHASE_SEQUENCE FAULT" -38-** is generated.

The firing unit can run with both network direction. The parameter facilitates to remember that when using a counter-clockwise direction, also other equipment like fans inside the cubicle must be taken into consideration.

19.3. Firing unit synchronisation

After closing of the main contactor and when the firing unit is once synchronised the program starts to supervise the synchronisation. If the synchronisation fails, the fault **NOT_IN_SYNCHRONISM -31-** will be generated.
The synchronisation of the firing unit takes typically aprx. 300 ms before the current controller is ready.

19.4. Fan, field and main contactor acknowledge

When the drive is started the program closes the FAN contactor and waits for acknowledge. After ack is received, the field contactor is closed and the program waits that the field ack is received. Finally the main contactor is closed and ack is waited.
If acknowledges are not received after 6 seconds of "ON" -command the corresponding fault is generated. These are:

NO_EXT_FAN_ACK	**-40-**
NO_MAIN_CONT_ACK	**-41-**
NO_FIELD_ACK	**-39-**
NO C FAN ACK	**-50-**

Two acknowledges can alternatively generate alarms. These are:

CONV.FAN.ACK.ALARM	**-126-**
EXT.FAN.ACK.ALARM	**-127-**

19.4.1. External FAN acknowledge

The function of the program can be selected in case where acknowledge information of the external fan(s) is not available:

EXT_FAN_ACK_MODE (11-12)

- **0** = drive is tripped and **NO_EXT_FAN_ACK**-fault will be given
- **1** = only **EXT_FAN_ACK**-alarm will be given.
- **2** = acknowledge not used.

19.4.2. Converter FAN acknowledge

Constructions C1,C2 and C3 generates alarm when the acknowledge signal is missing. The construction C4 generates fault.

20. CONVERTER PROTECTION

20.1. Armature overcurrent

Used overcurrent limit can be checked from the signal

I_TRIP_A **(113-02)** scale 1==1A

The limit can be reduced by the parameter:

ARM_OVCUR_LEV **(18-05)**

scale: % 100==nominal current of converter **I_CONV_A(113 01)**

20.2. Over temperature

The maximum temperature of the bridge can be checked from the signal

MAX_BRIDGE_TEMP(113-04) scale: 1=1C.

Exceeding this limit will cause the **"CONVERTER_OVERTEMP" -04-** fault. The alarm limit is 10C under the tripping limit.
The measured temperature can be monitored from the signal

BRIDGE_TEMP(118-14) scale 1=1C

20.3. Network over voltage

The over voltage limit is fixed 130% (1.3 * **U_SUPPLY (18-06)**). If the limit is exceeded longer than 10 seconds then the **"MAINS OVERVOLTAGE" -30-** fault will be generated.

21. MOTOR PROTECTION

21.1. Stall protection

The stall protection trips the converter when the motor is in apparent danger of overheating. The rotor is either mechanically stalled or the load is otherwise continuously too high. The selection of the stall protection is made by the parameter

STALL_PROT_SEL (11-14).

0 = Not used
1 = stall protection selected

The stall protection trips the drive when:

Actual speed is below the given limit.
Actual torque exceeds the given limit.
The condition last longer than given time.

Next parameters define limits for the stall protection:

STALL_SPEED **(15-16)**
Scale: speed unit, 200 = 1%

STALL_TORQUE **(15-17)**.
Scale: torque unit: 4000 = motor nominal

STALL_TIME **(15-15)**.
Scale: ms

21.2. Overspeed protection

The drive is protected against overspeed e.g. in a case where drive section is controlled by the torque reference and the load falls down unexpectedly.
The limit of the overspeed is set into the parameter:

OVSPEED_LIMIT (12-10) scale: speed units (0....30 000).

21.3. Measured motor temperature

Two motor temperatures can be measured at a same time. Both measurements have one alarm limit and one tripping limit. The limits are programmable.

The temperature measurements use AI-channels **AI2** and **AI3.**

the **SDCS-IOB-3**-board has one selectable current generator for the **PT100** (5 mA) or **PTC** (1.5 mA)-elements.

Unit of the measurement depends on the selected measurement mode. For PT100 the unit is Celsius.
For PTC the unit is ###.

21.3.1. Measurement selection

Max. 3 PT100 elements can be connected in serial. In case of only one PT100 element the AI-channel measurement range must be jumpered to use the voltage range 0...1V.

The selection for the measurements are done by the parameters:

MOT1_TEMP_AI_SEL (15-09) For analogue input 2
MOT2_TEMP_AI_SEL (15-12) For analogue input 3

0 = not used (default value)
1 = 1 x PT100 [°C], 5 mA current generator, voltage range **0..+1 V**
2 = 2 x PT100 [°C], 5 mA current generator, voltage range 0..+10 V
3 = 3 x PT100 [°C], 5 mA current generator, voltage range 0..+10 V
4 = PTC [Ω], 1.5 mA current generator, voltage range 0..+10 V
5 = current or voltage measurement ranges: -1 V...+1 V, -10 V..+10 V, 0/4...20 mA

When voltage or current measurement are selected **(5)** the scaling are made with the parameters:

AI2_HIGH_VALUE (16-05)
AI2_LOW_VALUE (16-06), analogue input 2

AI2_HIGH_VALUE (16-07)
AI2_LOW_VALUE (16-08), analogue input 3

Note. These scaling are not used with measurements which are based on the PT100 and the PTC-elements.

Measured values can be monitored from signals:

MOT1_MEAS_TEMP (115-03), analogue input 2
MOT2_MEAS_TEMP (115-04), analogue input 3

The unit for the measurement:

PT100: Celsius
PTC: ohms
Other: Scaled value.

21.3.2. Alarm and tripping limits

The over temperature fault belongs to tripping level 2. In case of over temperature the main and the field contactors will be opened but fans are kept run until temperature falls under the alarm limit.

In the PT100-measurement alarm and tripping limits are set directly as Celsius-degrees.
In the case of thermistor measurement (PTC) limits are set as resistance values. (0...4000 ohms).

Alarm levels can be set by the parameters:

MOT1_TEMP_ALARM_L(15-10), analogue input 2
MOT2_TEMP_ALARM_L(15-13), analogue input 3

Tripping limits can be set by the parameters:

MOT1_TEMP_FAULT_L(15 11), analogue input 2
MOT2_TEMP_FAULT_L(15 14), analogue input 3

When some limit is set to zero then the appropriate function is by-passed.

21.4. Motor thermal model

21.4.1. General

In DCV700 there are two thermal models that can be used at a same time. Two models are sometimes needed when one converter is switched between two motors, e.g. shared motion drive sections. By means of one signal the measured armature current is directed to wanted model. In normal case only one thermal model is needed.

The thermal model of the motor is recommended to use when a direct temperature measurement from the motor is not available and the current limits of the drive are set higher than used motor nominal current.

The thermal model does not directly calculate the temperature of the motor. The thermal model calculates the ***Temperature rise*** of the motor based on the fact that when starting to run the cold motor with nominal current the motor will reach the end temperature after the specified time. This time is about four times the motor thermal time constant.

The temperature rise of the motor behaves like the time constant which is proportional to the motor current power of two.

$$\Phi = \frac{I_{act}^2}{I_{ref}^2} * (1 - e^{-t/\tau}) * 100 \qquad (1)$$

where

Φ	temperature rise
I_{act}	motor current
I_{ref}	reference current, Normally rated current of motor.
τ	temperature time constant.
100	scaling factor

When the motor is cooling down, the temperature model follows next formula

$$\Phi = \frac{I_{act}^2}{I_{ref}^2} * e^{-t/\tau}) * 100 \qquad (2)$$

As from the formulas (1) and (2) can be seen, the temperature model uses the same time constant when motor is heating or cooling down.

21.4.2. Thermal model selection

The activation of thermal models is made by parameter

TEMP_SUPERVISION (11-06)

If both thermal models are activated, then by means of signal

MOTOR2 (101-07)

the APC can select which thermal model follows armature current measurement. The input value for the not selected one is always zero. So one thermal model follows armature current and second one will cooling down.
If the thermal model is not activated, its output is forced to zero.

21.4.3. Alarm and tripping limits

Alarm and tripping limit calculations use as a base current (I_{ref}) a value given by parameters

TEMP_MODEL1_CUR (15-02)

TEMP_MODEL2_CUR (15-06)

The normal value is 4096 (≡ motor rated current). This value should not normally be changed. If , for some reason, it is not possible to run the motor continuously with rated current, e.g. poor cooling environment, then the value can be decreased. E.g. the wanted continuous load is 85% of the used motor rated current. The value for parameters are then 0.85 * 4096 = 3481.

Alarm and tripping limits can be selected by means of four parameters

TEMP_MODEL1_ALARM_L (15-03)
TEMP_MODEL1_TRIP_L (15-04)

TEMP_MODEL2_ALARM_L (15-07)
TEMP_MODEL2_TRIP_L (15-08)

Default values are selected so that the overload ability is quite high. E.g. the current must continuously be √120 * 100 = 109.5 % before alarm is given and for trippings the current must be √130 * 100 = 114 %.

Recommended values for alarms is 102% and for trippings 106%.

Value for recommended alarm	104	$(100 * 1.02^2)$
Value for recommended trip	112	$(100 * 1.06^2)$

21.4.4. Thermal time constant

The time constant for both thermal models are given by two parameters

TEMP_MODEL1_TC (15-01)
TEMP_MODEL2_TC (15-05)

One has to bear in mind that the thermal time constant cannot be used directly when calculating the tripping time. Many cases the motor manufacturer presents a curve that defines how long the motor can be overloaded with certain overload factor. In this case the right thermal time constant must be calculated.

Example:
The drive is wanted to trip when motor current rise above 170% of motor nominal current longer than 1 minute.
Selected tripping base level is 106%. **TEMP_MODEL1_TRIP_L** P15-04 = 112.

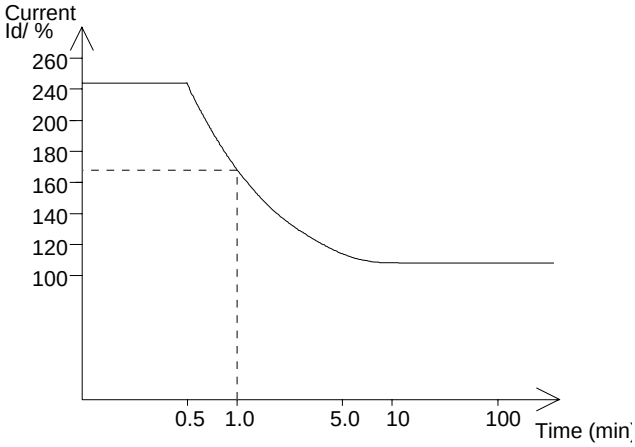


Figure 33 Motor load curve.

Note: this is an example and does not necessarily correspond to any motor !

Using formula (1) we can solve a correct value for τ:

Formula:

$$1.7^2 * (1 - e^{-1/\tau}) = 1.12 \quad (3)$$

Solve an equation concerning τ :

$$2.89 - 2.89 * e^{-1/\tau} = 1.12 \quad (4)$$

$$1.77 / 2.89 = e^{-1/\tau} \quad (5)$$

$$\ln 1.77 / 2.89 = - 1/ \tau \quad (6)$$

$$\tau = 1 / 0.49 \quad (7)$$

$\underline{\tau = 2.04 \text{ min}}$

Select **TEMP_MODEL1(2)_TC** = 60 * 2.04 = 122

21.5. KLIXON

The temperature of the motor can also be supervised by using Klixon.The klixon is a kind of thermal switch which opens the contact at a defined temperature. This can be used for supervision of the temperature by connecting the switch to some digital input of the DCV 700. The digital input for the Klixon are selected by the parameter

KLIXONSEL (15-18)

21.6. Armature over voltage

The nominal value (100%) of the armature voltage is

1.35*U_SUPPLY (18-06)

The setting of the over voltage limit is based on this value. The limit is set into the parameter

ARM_OVERVOLT_ LEV (15-22) Scale: %
default 110==110%.

When exceeding the limit the ARMATURE_OVERVOLTAGE -28- fault is generated.

22. AUTOTUNING

The parameters of the armature current controller can be defined by using the autotuning function. After nominal values of the motor and the converter are given to the function, the autotuning feature can be executed.
To start the autotuning follow next steps:

Open the main contactor.
Set parameter **DRIVEMODE (11-04)** to 3
Close the main contactor and **start** the converter within 20 seconds.

Tuning is over when the **DRIVEMODE (11-04)** changes back to zero. The converter stops automatically.

If the drive trips during the autotuning, the program sets -1 to the **DRIVEMODE (11-04)**.

The reason for tripping can be seen from the signal **COMMIS_STAT (101-06)**.

Fault codes of the signal **COMMIS_STAT(101-06):**

49: Field not nominal during start

50: Ohmic load not determined.

51: Current feedback is less than current reference during measurement of armature resistance. Current limits lower than the limit for continuous current flow or lower than 20%.

52: Inadmissible current curve. Fuse blown, thyristor not firing or no motor load.

53: Wrong starting conditions. The drive is running when the autotuning is started or run command is not given within 20 s after start of autotuning.

54: Too high speed during autotuning .Speed greater than 1% or EMF greater than 15%.

55: Inductance cannot be determined. Fuse blown, thyristor not firing or no motor load.

56: Limit for continous current flow cannot be determined.

57: The field removal takes longer time than 10 s.

58: Blocking or stop signal appears during autotuning.

23. MANUAL TUNING

In order to facilitate the tuning of the drive, DCV700 has several manual tuning functions. With help of the manual tuning next functions can be tuned:

Armature current controller
Field exciters
EMF controller
Speed loop

When manual tuning is activated, normal reference is switched off from the function and replaced by test reference. The test reference can be either Square wave generator or adjustable test-reference.

Manual tuning can be activated only in LOCAL-mode.

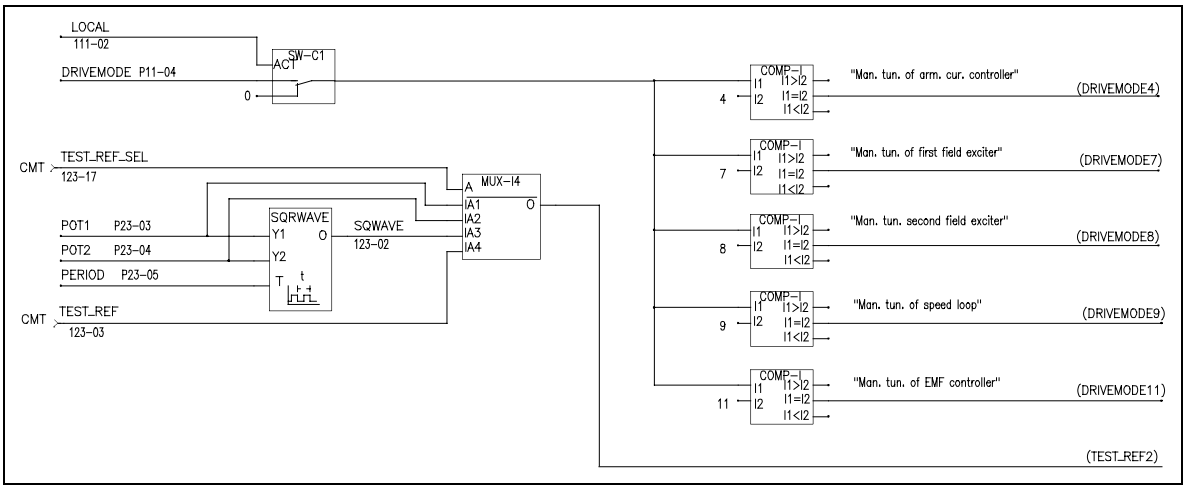


Figure 34 Object and test reference selections in the manual tuning.

The activation of the manual tuning parameter:

DRIVEMODE(11-04)

4= armature current controller
7= first field exciter
8= second field exciter
9= speed loop (reference chain and speed controller)
11= EMF controller

23.1. Square Wave generator

The output of the square wave generator is adjusted by using 3 parameters:

POT1 (23-03) Higher value of the generator
POT2 (23-04) Lower value of the generator

PERIOD (23-05) Time between values.
Scale: 1 = 10 ms

The output of the square wave generator can be monitored from the signal

SQRW (123-02)

23.2. Test reference selection

The test reference can be selected by the signal

TEST_REF_SEL (123-17)

0= 0
1= **POT1 (23-03)**
2= **POT2 (23-04)**
3= **SQWAVE (123-02)**
4= **TEST_REF (123-03)**

Finally start the drive or only close main contactor in a case of field exciters. Measurements are recommended to do with DDCTool.

23.3. Manual tuning of the speed loop

The test reference replaces LOCAL_SPEED_REF that normally comes from the DDCTool. When using the square wave function, the drive can be set to accelerate and decelerate continuously without giving the new reference from the DDCTool.
Used when acceleration compensation is tuned.

23.4. Manual tuning of field exciters

The test reference replaces normal field exciter references coming from the controlling software. When using the square wave function, the field reference can be stepped. Actual values **FIELD1(2)_CUR_ACT 118-10(12)** can be monitored by the DDCTool and with help of reference and actual value monitoring the gain values can easily be adjusted.

23.5. Manual tuning of Armature Current Controller

During the test the field contactor is automatically opened to prevent the motor running.

Test reference replaces the ARM_CUR_REF, current limits is not by-passed.

23.5.1. Find continuous/discontinuous current limit

The continuous current limit can be found by slowly increasing the current reference and at a same time by monitoring with the DDCTool the bit **CONTINOUS_CURR (9)** in **AUX_STATUS_WORD (101-05)**. The limit is reached when the bit-signal oscillated in the DDCTool screen.

After the limit is reached , the actual current is read and the value is set to the limit parameter:

CONV_CUR_ACT (118-05) ARM_CONT_CUR_LIM(7-06)

23.5.2. Tuning of the armature current controller

After discontinuous current limit is defined, the PI-controller can be tuned normally either using square wave -function or step buttons of the DDCTool.

23.6. Manual tuning of the EMF-controller

Before tuning of the EMF-controller the field controller must first be tuned .

The tuning principle

The motor is started to run about half speed of the used field weakening area.
The signal **EMF_ACT (108-06)** is read and the value is used for defining used steps. The higher value of the step can be the value that are read. The lower value of the step can be 15% less.
The autotuning function is activated. Steps can be given either using square wave generator or step -buttons of the DDCTool.
Using steps gain values of PI-controllers are tuned.

24. LIMITATIONS

24.1. Torque and armature current limitation

Torque and current limits can be selected independently. If selected armature current limits are smaller than selected torque limits, the program automatically limits used torque limits so that the output of the speed controller cannot be bigger than the torque the current controller can produce.

Armature current can also be limited proportionally to the actual speed.

Limits for the armature current are set by parameters:

ARM_CUR_LIM_P (12-05),	scale: 4095=	**I_MOTN_A(13-02)**
ARM_CUR_LIM_P (12-06),	scale:-4095=	**I_MOTN_A(13-02)**

Speed dependent limits for the armature current are set by parameters:

MAX_CUR_LIM_SPEED (13-04)	The speed level for armature current limit reduction. 20000 = max. speed.
ARM_CUR_LIM_N1 (13-05)	Armature current limit at speed 13-14
ARM_CUR_LIM_N2 (13-06)	Armature current limit at speed [13-04] + (20000 - [13-04])/4
ARM_CUR_LIM_N3 (13-07)	Armature current limit at speed [13-04] + 2*(20000 - [13-04])/4
ARM_CUR_LIM_N4 (13-08)	Armature current limit at speed [13-04] + 3*(20000 - [13-04])/4
ARM_CUR_LIM_N5 (13-09)	Armature current limit at speed 20000

Torque limits are set by the parameters:

TORQMIN (12-02)	scale: 4000 = Tn(motor)
TORQMAX (12-01)	scale: -4000 = Tn(motor)

Used torque limit can be monitored from signals

TORQ_MIN2 (112-05)
TORQ_MAX2 (112-06)

24.2. Gear backlash compensation

The gear backlash compensation function can be used for backlash-affected drives. When the torque reference passes through zero, at first only small torque limits are used. After the **GEAR_TORQ_TIME (12-14)** has elapsed the torque limits are stepped to the defined level.

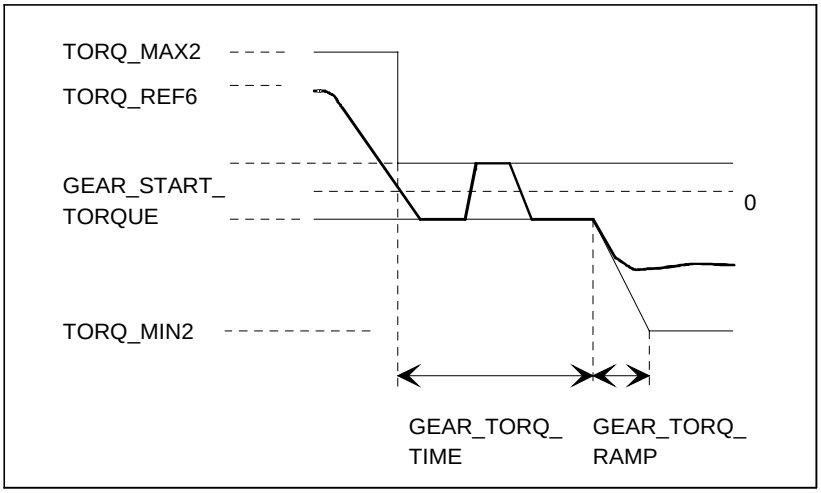


Figure 35 Torque limitation during gear backlash.

The gear backlash function is adjusted by setting next parameters

GEAR_START_TORQ (12-13) When the torque is changing the direction, torque limits are reduced for a while. GEAR_START_TORQ is the torque limit right after the direction changes. Scale: 4000 = motor nominal torque

GEAR_TORQ_TIME (12-14) The time after the direction change when GEAR_START_TORQ is used. Scale: ms

GEAR_TORQ_RAMP (12-15) When the torque is changing the direction, torque limits are reduced for a while. GEAR_TORQ_RAMP defines the slope to the normal torque limit after GEAR_TORQ_TIME is elapsed : maximum change of limit/3.3 ms (2.7 ms 60 Hz) .

24.3. Speed reference limitation

The speed reference is limited by parameters:

SPEED_MAX (12-03), scale: speed units
SPEED_MIN (12-04), scale: speed units

Speed reference 20000 equals to the speed which is set into the parameter **SPEED_SCALING (13-18)** [0.1 rpm].

24.4. Zero speed limit

Zero speed limit is set into the parameter

ZERO_SPEED_LIMIT (12-09). Scale: speed unit

The limit defines the speed when the drive finishes to generate current when the stop-command is given.

The indication of the zero speed can be monitored from signal

ZEROSPEED (114-04).

0 = absolute speed bigger than **ZERO_SPEED_LIMIT (12-09)**
-1 = absolute speed less than **ZERO_SPEED_LIMIT (12-09)**

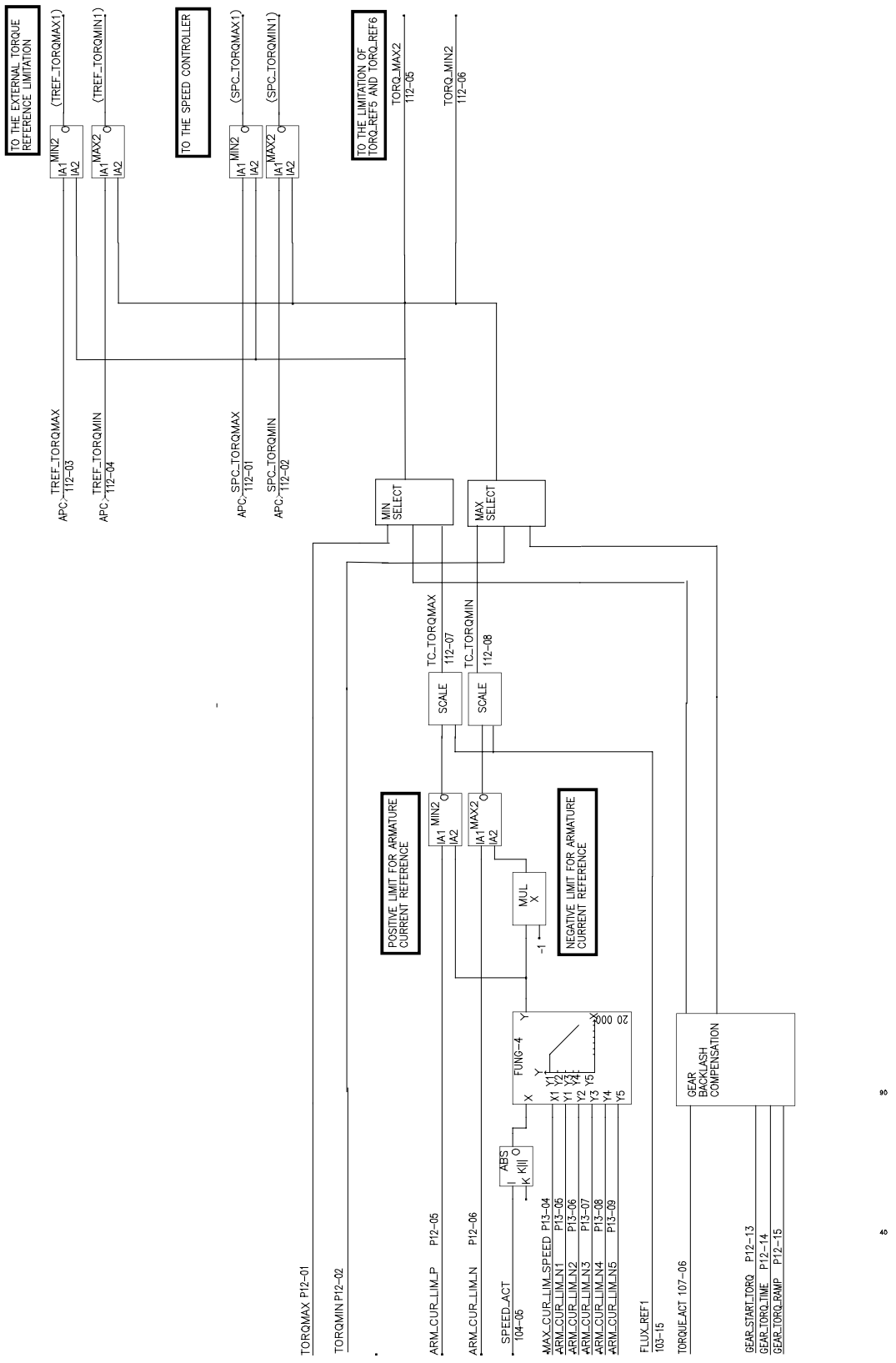


Figure 36 Torque and armature current reference limitation.

25. CONVERTER SETTINGS

25.1. Converter rating plate data

With converter types **C1,C2** and **C3** nominal values of the converter are based on the coding resistors of a PIN-board. These values are nominal current, nominal voltage ,maximum bridge temperature, converter type and quadrant type. Values can be checked from signals:

I_CONV_A (113-01)	1 = 1 A
U_CONV_V (113-03)	1 = 1 V
MAX_BRIDGE_TEMP (113-04)	1 = 1 °C
CONVERTER_TYPE (113-05)	1 = C1, 2 = C2, 3 = C3, 4 = C4
QOUDRANT_TYPE (113-06)	1 = 1Q,4 = 4Q

Values are used for scaling measurements and tripping levels.

If nominal values are necessary to change, that can be done by parameters which overwrite the information of coding resistors.

SET_I_CONV_A (18-07)	1 = 1 A
SET_U_CONV_V (18-08)	1 = 1 V
SET_MAX_BRIDGE_TEMP (18-09)	1==1 °C
SET_CONVERTER_TYPE (18-10)	1 = C1,2 = C2,3 = C3,4 = C4
SET_QUADRANT_TYPE (18-11)	1 = 1Q, 4 = 4Q

0 = coding resistors are used
<>0 coding resistor are overwritten

C4 converter doesn't have coding resistors. For C4-type of converter nominal values must be given by using SET... parameters.

Values can be read from the converter rating plate.

25.2. Nominal network voltage

The nominal voltage of the network must be given to program by means of the parameter.

U_SUPPLY (18-06) scale:1==1V

If the value is not defined, the default value is same as converter nominal voltage **U_CONV_V(113-03)**.

26. MOTOR SETTINGS

In order to ensure proper and optimal control of the motor, the program needs information about the motor. The rating plate data of the motor are given as following:

U_MOTN_V (13-01) scale: 1==1V. The value is used for scaling measured/calculated actual speed which is based on EMF (SPEED_ACT _EMF)

I_MOTN_A (13-01) scale: 1==1A.The value is used for scaling the armature current by means of measured converter current.

I_MOT1_FIELDN_A (13-03) scale: 1=0.01A. The value is used for scaling field current measurement.

27. PARAMETER BACKUP

All parameters of converter and field exciters can be stored in the FPROM memory-circuit (D35) in the control card. Backup mode of the FPROM is selected by means parameter

BACKUP_STORE__MODE (11-07).

0= no backup.
1= backup to FLASH memory. After writing the mode is changed to 0.
2= reserved.
3= default values are restored to the RAM. After reading values the mode is automatically changed to 0.

During backup-function operation an internal counter counts down from 255 to 0. The value of the counter can be monitored from the **BACKUP_STORE_MODE (11-07)**. When the value of the counter has reached 0, the backup is done.

If different value than zero appears during backup means this some kind of fault. Possible reasons are listed below:

5= unknown/missing FPROM
7= erasing failed
9= programming failed

28. DIAGNOSTIC

DCV700 has versatile diagnostic functions in order to monitor HW-functions and to facilitate trouble-shooting. Function are:

Control board self diagnosing
Supply voltage monitoring
Watchdog
Fault logger
Data logger

Diagnostic information are divided into 2 main classes. These are:

ALARM	An announcement that some limit is reached. Alarm does not prevent the drive to run.
FAULT	The drive is always tripped.

Faults and alarms have a numerical code and 20 character long text for fault logger. Codes that are numbered between 0 and 99 are reserved for faults. Code numbers bigger than 100 are reserved for alarms. The text language is English.
The control board **SDCS-CON-1** has the giant capacitor that supplies power to the memory circuits during supply voltage shut-down in order to keep data in the fault logger and the data logger.

28.1. Control board self diagnostic

The control board has one 7-segment display in order to facilitate trouble-shooting in various situations.

After switching on the supply voltages for the control board, the program starts to test HW. During initialization RAM and ROM (flash memories) memories are tested.
If ROM or RAM tests fail, the communication will not start and an error message will appear on the control board 7-segment display (E 1 or E 2).
The diagnostic tests also that the communication board SDCS-COM-1 exist. The board is compulsory because that is the only way to control the drive.

Such faults that would prevent to start running the program totally is shown by the 7-segment display always with the letter:

E and code.

During normal running fault codes and alarm codes shown by the 7-segment.

If message/error code has more than one number or letter to display, the code is displayed so that every number and letter are alternating with each others in the period of 0.7 seconds . This sequence is repeated indefinitely.

The seven segment display is located on the control board. Codes are:

Code		Description
0.7 s	0.7 s	
.		Normal situation, no fault no alarm
L		During downloading (PC->drive) sequence
8		Program is not running
E	1	ROM memory test error
E	2	RAM memory test error
E	3	No TC link board
E	4	Bad TC-link board
E	5	No control program in memory
E	6	Incompatible hardware
A	XX	Alarm code
F	XX	Fault code

Table 37. Status codes of the drive shown on the seven segment display of the SDCS-CON-1 .

28.2. Supply voltage monitoring

The control board monitors the following voltage levels:

Supply voltage	Under voltage limit
+5 V	+4.55 V
+15 V	+12.4 V
-15 V	- 12.0 V
+24 V	+19 V
+48 V1	+38 V

If +5 V drops under the tripping limit, it causes a master reset by hardware causing a power fail message to be displayed and the firing pulses are suppressed.

28.3. Watchdog function

The control board contains an internal watchdog. The watchdog supervises program running on the control board. If watchdog trips the HW takes care of the next functions:

FPROM programming voltage is forced low.
Thyristor firing control is reset and disabled.
Digital outputs are forced low
Programmable analogue outputs are reset to zero, 0V.

28.4. Jumpers on the SCDS-CON-1 board

By means of jumpers S2 and S3 user can by-pass the backup-flash reading at a power-up state and disable totally writing to the backup-flash.

Jumpers must not be removed or connected when power is on!

Jumpers have four pins and the pins are marked on the circuit board beside each jumper. The following table shows factory settings of the jumpers.

JUMPER	Factory settings	Comments
S2	3-4	1-2: the program starts with initial parameters.
S3	3-4	1-2: Programming of the FPROMs are disabled. (also download !)

28.5. Fault logger

The fault logger contains 100 latest events generated by the diagnostic program. Every event has a code, time mark and 20 character long text in English.
Alarms have marked by (+) when alarm is coming and by the mark (-) when alarm is disappearing.
Fault logger can be uploaded either by DDCTool or by APC.

The latest event can be checked by reading signal

LATEST_FAULT (122-05)

28.6. Real time clock

DCV 700 has a real-time clock which is used by the fault logger to add time mark to fault logger entries. DCV 700 updates the real-time clock at a 20 ms interval. APC can synchronise the real-time clock with the broadcast message that contains new time and date values.
DCV 700 handles time and date as the 32-bit long integer variables. Because the TC-Link Protocol handles only 16-bit values, time and date variables are divided into four separate 16-bit values:

TIME_LOW (122-01)
TIME_HIGH (122-02)
DATE_LOW(122-03)
DATE_HIGH (122-04)

28.7. Data logger

The data logger allows to collect data from the certain process event in order to later examine the collected data in graphical or in numerical form.

The data logger can be triggered either manually or when some of the trigger conditions has been fulfilled.

Data logger consists of six logging channels

DLOG1_DATA (121-01)
DLOG1_DATA (121-02)
DLOG1_DATA (121-03)
DLOG1_DATA (121-04)
DLOG1_DATA (121-05)
DLOG1_DATA (121-06)

The capacity of each channels are 1000 samples. Values are read either by DDCTool or by APC.

The collection time (1...1000s) can be set by the sampling interval parameter

DLOG_SAMPL_INT (21-10) (1...1000 ms). The collection time is common for all channels.

Selection of the parameter/signal index which are wanted to be sampled are set to the parameters:

DOG1_INDEX (21-01)
DOG2_INDEX (21-02)
DOG3_INDEX (21-03)
DOG4_INDEX (21-04)
DOG5_INDEX (21-05)
DOG6_INDEX (21-06)

Trigger condition selection is made by means of the parameter

DLOG_TRIGG_COND (21-07)

0= external triggering from APC, positive edge of **bit 9** in the **MAIN_CONTROL_WORD (101-01)**
1= fault or external triggering from APC
2= triggers when the difference of two successive values of data logger **channel 1** is larger than the value defined in **DLOG_TRIGG_VALUE (21-08)**
3= triggers when the value in data logger **channel 1** exceeds the value which is defined in **DLOG_TRIGG_VALUE(21-08)**
4= triggers when the value in data logger **channel 1** falls below the value which is defined in **DLOG_TRIGG_VALUE(21-08)**.

Number of samples **after triggering** can be defined by the parameter

DLOG_TRIGG_DELAY (21-09), 0 ... 1000 samples.

The status of the data logger can be read from the signal

DLOG_STATUS (121-07).

0 = logger is empty
1 = logger is collecting data
2 = a trigger has occurred
3 = logger has stopped after the trigger
4 = logger has stopped after the stop command
5 = logger has stopped after the trigger and the stop command

28.8. Monitoring of the APC application signals

DCV700 has 8 free signals which are not used by the DCV700 software. These can be used for measuring APC -signals by the DDCTool.

DLOG_APC1 (121-08)
DLOG_APC1 (121-09)
DLOG_APC1 (121-10)
DLOG_APC1 (121-11)
DLOG_APC1 (121-12)
DLOG_APC1 (121-13)
DLOG_APC1 (121-14)
DLOG_APC1 (121-15)

28.9. Fault and alarm texts and codes

Signal Code	Definition [Fault text]	Type of Signal	Mode of Action	Reset Method
0	No faults or alarms			
99	Resets all resettable faults [**Reset**]	Reset		
1	Auxiliary voltage fault [**Auxil. undervoltage**]	Fault	Trips	To be reset
2	Armature overcurrent [**Overcurrent**]	Fault	Trips	To be reset
4	Measured over temperature of converter [**Converter overtemp.**]	Fault	Trips	To be reset
5	[**Earth fault**]	Fault	Trips	To be reset
6	Measured over temperature of motor 1 [**Motor 1 overtemp.**]	Fault	Trips	To be reset
7	Calculated over temperature of motor 1 [**Motor 1 overload**]	Fault	Trips	To be reset
14	Speed measurement fault [**Speed meas. fault**]		Trips	To be reset
17	Type code of the converter not found [**Type coding fault**]		Trips	Can't be reset
18	Parameter backup fault [**Par backup fault**]		Trips	Can't be reset
20	APC-link communication error [**APC-Link comm.error**]	Fault	Parameter dependent.	To be reset
21	APC watch-dog time-out [**APC watch-dog error**]	Fault	Parameter dependent.	To be reset
23	[**Motor stalled**]	Fault	Trips	To be reset
27	Calculated over temperature of motor 2 [**Motor 2 overload**]	Fault	Trips	To be reset
28	Armature DC over voltage [**Armature overvoltage**]	Fault	Trips	To be reset

Signal Code	Definition	Type of Signal	Mode of Action	Reset Method
29	Main AC supply under voltage [**Mains under voltage**]	Fault	Trips	To be reset
30	Main AC supply over voltage [**Mains over voltage**]	Fault	Trips	To be reset
31	Firing unit synchronization fault [**Not in synchronism**]	Fault	Trips	To be reset
32	Field exciter 1 overcurrent [**Field Ex. 1 overcurr**]	Fault	Trips	To be reset
33	Field exciter 1 comm. error [**Field Ex. 1 comerror**]	Fault	Trips	To be reset
34	Armature current ripple [**Arm. current ripple**]	Fault	Trips	To be reset
35	Field exciter 2 overcurrent [**Field Ex. 2 overcurr**]	Fault	Trips	To be reset
36	Field exciter 2 comm. error [**Field Ex. 2 comerror**]	Fault	Trips	To be reset
37	Motor overspeed [**Motor overspeed**]	Fault	Trips	To be reset
38	AC input hase sequence fault [**Phase sequence fault**]	Fault	Trips	To be reset
39	Missing field acknowledge [**No field ack.**]	Fault	Trips	To be reset
40	Missing ext. FAN acknowledge [**No ext. FAN ack**.]	Fault	Trips	To be reset
41	Missing main contactor acknowledge [**No main cont. ack**]	Fault	Trips	To be reset
42	First field exciter status not OK [**Field_Ex_1_Not_OK**]	Fault	Trips	To be reset
43	Second field exciter status not OK [**Field_Ex_2_Not_OK**]	Fault	Trips	To be reset
44	Some I/O-board missing [**I/O-Board not found**]	Fault	Trips	Can't be reset
48	Measured overtemperature of motor 2 [**Motor 2 overtemp**.]	Fault	Trips	to be reset
50	Missing converter FAN acknowledge [**No C FAN ack**]	Fault	Trips	to be reset

Signal Code	Definition [APC alarm/status texts]	Type of Signal	Mode of Action	Reset Method
101	Inhibition of false start switch has been switched [**Start inhibition**]	Status	Prevents start up	Resets when released
102	Emergency stop button has been pushed [**Emergency stop**]	Status	Prevents start up	Resets when released
103	Motor1 measured temperature [**Motor 1 temp. alarm**]	Alarm	Alarm indicator	Self reset
104	Motor 1 thermal model alarm [**Motor 1 overl.alarm**]	Alarm	Alarm indicator	Self reset
105	Converter unit temperature measurement [**Conv. overtemp. alarm**]	Alarm	Alarm indicator	Self reset
106	TC unit address not in limits [**TC address alarm**]	Alarm	Alarm indicator	Address to be set in limits
108	Backup failure of RAM memory [**RAM-backup failed**]	Alarm	Alarm indicator	Self reset (after first run)
110	System cold start [**System restart**]		Status indicator	Self reset after init.
112	Master/Follower index is incorrect [**Mas.Foll.index alarm**]	Alarm	Alarm indicator	Self reset
114	APC communication started [[**APC connection OK**]	Alarm	Alarm indicator	Self reset
118	Main supply under voltage [**Mains underv.alarm**]	Alarm	Alarm indicator	Self reset
120	Armature current deviation [**Arm.curr.dev.alarm**]	Alarm	Alarm indicator	Self reset
123	Motor2 temperature measurement [**Motor 2 temp. alarm**]	Alarm	Alarm indicator	Self reset
124	Motor2 thermal model alarm [**Motor 2 overl.alarm**]	Alarm	Alarm indicator	Self reset
125	Master/Follower time-out [**Mas.Foll. tout alarm**]	Alarm	Alarm indicator	Self reset
126	Missing acknowledge of conv. FAN [**Conv.FAN-ack.alarm**]	Alarm	Alarm indicator	Self reset
127	Missing acknowledge of ext. FAN [**Ext.FAN ack.alarm**]	Alarm	Alarm indicator	Self reset
128	APC link close command received [**APC link closed**]	Alarm	Alarm indicator	Self reset
129	Type code changed during power down [**Type code changed]**	Alarm	Alarm indicator	Self reset
130	Gap in AC-voltage noticed. [[**Auto-reclosing]**	Alarm	Alarm indicator	Self reset
132	Aux.voltage switched off (OFF-state) [**Aux.underv.alarm]**	Alarm	Alarm indicator	Self reset

28.10. Combined fault words

Index **12206**	**FAULT_WORD1** - combined fault word 1	
Scaling: see below	Read only	Type : PB
Bit	**Fault text**	**Signal code** (fault code)
0	Auxil. under voltage	1
1	Overcurrent	2
2	Armature over voltage	28
3	Converter overtemp	4
4	Earth fault	5
5	**Motor 1** overtemp (measured)	6
6	**Motor 1** overload (thermal model)	7
7	I/O board not found	44
8	**Motor 2** overtemp. (measured)	48
9	**Motor 2** overload (thermal model)	27
10	APC watch-dog error	21
11	Mains under voltage	29
12	Mains over voltage	30
13	Not in synchronism	31
14	**Field Ex. 1** overcurr	32
15	**Field Ex. 1** comerror	33

Index **12207**	**FAULT_WORD2** - combined fault word 2	
Scaling: see below	Read only	Type : PB
Bit	**Fault text**	**Signal code** (fault code)
0	Arm. current ripple	34
1	**Field Ex. 2** overcurr	35
2	**Field Ex. 2** comerror	36
3	Phase sequence fault	38
4	No field ack	39
5	Speed meas fault	14
6	No ext. FAN ack.	40
7	No main cont. ack.	41
8	Type coding fault	17
9	Par backup fault	18
10	No C FAN ack	50
11	APC-Link comm. error	20
12	Field_Ex_1_Not_OK	42
13	Field_Ex_2_Not_OK	43
14	Motor stalled	23
15	Motor overspeed	37

28.11. Combined alarm words

Index **12208**	**ALARM_WORD1** - combined alarm word 1	
Scaling: see below	Read only	Type : BOOLEAN
Bit	**APC alarm/status text**	**Signal code** (alarm/status code)
0	Start inhibition	101
1	Emergency stop	102
2	**Motor 1** temp. alarm	103
3	**Motor 1** overl. alarm	104
4	Conv. overtemp alarm	105
5	TC address alarm	106
6		
7	Ram-backup failed	108
8	**Motor 2** temp. alarm	123
9	**Motor 2** overload alarm	124
10	Mains underv alarm	118
11	Mas. foll. index alarm	112
12	Conv.FAN. ack alarm	126
13	Arm. cur.dev.alarm	120
14	Mas. Foll.tout alarm	125
15	Ext. FAN.ack.alarm	127

Index **12209**	**ALARM_WORD2** - combined alarm word 2	
Scaling: see below	Read only	Type : BOOLEAN
Bit	**APC alarm/status text**	**Signal code** (alarm/status code)
0	APC-link closed	128
1	Type code changed	129
2	Aux.underv.alarm	132
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

28.12. Static fault and alarm words

All faults and alarms are copied to the static fault- and alarm words. These words hold their information although the alarm disappears or the "reset"-command is issued from APC or DDCTool.

Static fault- and alarm words can be reset by using bit 2 (**STATIC_RESET**) in **AUX_CONTROL_WORD (101-02)**.

If any of the static fault bits is set, this is informed by **AUX_STATUS_WORD (101-02)** bit 13 (**STATIC_FAULT**).

If any of the static alarm bits is set, this is informed by **AUX_STATUS_WORD (101-02)** bit 14 (**STATIC_ALARM**)

STATIC_FAULT_WORD1 (122-10)
STATIC_FAULT_WORD2 (122-11)
STATIC_ALARM_WORD1 (122-12)
STATIC_ALARM_WORD2 (122-13)

29. COMMUNICATION

DCV 700 has three optical fibre communication channels in the **SDCS-COM-1** board. Two of these channels run at 1.5 Mbits/s using the HDLC protocol. They are used for APC and DDCTool communication. The third channel is asynchronous protocol with a speed of 25 kbits/s. That channel is used for master/follower communication.

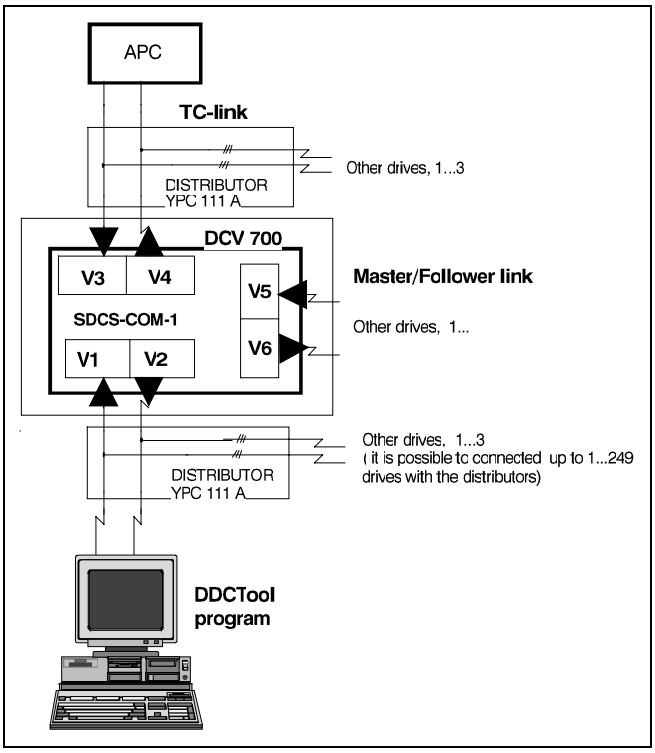


Figure 38 Basics of the DCV 700's communication.

29.1. TC-link protocol

TC-link protocol is used in communication between APC and DCV 700. The TC-link protocol supports two types of services: cyclic messages and service messages.
Cyclic messages are not acknowledged and the previous value is used until a new one is received correctly.
The cyclic communication operates cyclically with short update intervals and the update time is equidistant.

Cyclic communication messages are:

Basic message
Cyclic message
Broadcast message

In service communication every message must be transferred from the sender to the receiver. If there is an error in transmission, the message is repeated.

Service communication messages are:

Fault Upload Message
Parameter Download Message
Parameter Upload Message
Communication Management Message
Service Tool Message.

In Cyclic Communication both APC and DCV are initiators of communication, while in Message based communication the APC is the initiator in all messages.

29.2. Message types

A DATA-field of a TC-link frame can contain one or two messages. In case of two messages the first is always the Basic Message. Structure of the DATA field:

A frame with Basic Message only.

BASIC MESSAGE

- time interval 2...8 ms (1... 4 drive(s) are connected to the APC)

A frame with Basic Message and the second message.

BASIC MESSAGE	MESSAGE 2

- time interval 2...8 ms depends on application program of the APC.
- message 2 could be a cyclic message or a service communication message. A frame with a second message only

MESSAGE 2

29.2.1. Basic message

When the drive is controlled through a communication link, there are some basic requirements for the communication protocol. First the communication has to operate cyclically with short update intervals and secondly the update must be equidistant. In the TC-link protocol this is achieved with the Basic Message that is included in all frames during normal operation. So every frame from APC updates reference values in DCV 700 and every frame from DCV 700 updates values in APC.

Basic Message from APC to DCV 700:

REFERENCE 1	REFERENCE 2	REFERENCE 3

REFERENCE 1, 16-bit integer value, e.g. MAIN_CONTROL_WORD
REFERENCE 2, 16-bit integer value, e.g. SPEED_REFERENCE
REFERENCE 3, 16-bit integer value, e.g. SPEED_CORRECTION

Basic Message from ACV 700 to APC:

ACTUAL 1	ACTUAL 2	ACTUAL 3

ACTUAL 1, 16-bit integer value, e.g. MAIN_STATUS_WORD
ACTUAL 2, 16-bit integer value, e.g. SPEED_ACT
ACTUAL 3, 16-bit integer value, e.g. TORQUE_ACT

29.2.2. Cyclic message

Cyclic Messages are used to carry signals between APC and DCV 700. Cyclic Messages are needed if the reference and actual values of the Basic Message are not enough to control the DCV 700.

Use of Cyclic Messages should be limited to lowest level that is enough to control the DCV 700. Extensive use of Cyclic Messages also loads the DCV 700's software. A relative load from sending of Cyclic Message from the DCV 700 to APC can be read out from the signal **LOAD_FROM_CYC_MSGS(119-02)**.

29.2.3. Broadcast message

The message is used for broadcast sent by the APC.
The APC sends a broadcast message to all DCVs that are connected to it. The DCVs do not send any response frames to the APC. The Broadcast Message is always sent without the Basic Message. With the Broadcast Message it is possible to carry out the Master/Slave-communication. The master DCV sends e.g. **TORQ_REF6 (103-07)** to the APC, which sends it further to the slave DCV(s).

The minimum theoretical transmission interval is 8 ms. In practice the interval is longer than this because other messages are transmitted on the link and number of the DCV 700s can be more than two.

29.2.4. Fault upload message

APC sends a Fault Message-request to the DCV if the DRFLT block is activated to upload fault information. The DCV responds with Fault Message-response, which contains a fault code and the time and date when the fault occurred.

29.2.5. Parameter download message

APC sends a parameter download request message which contains indexes and values for max. five parameters. When background communication task in the DCV has processed the message, it gives a response message to the TC-link driver. The parameter downloaded response message is returned when the next poll arrives and there are no other higher priority messages waiting for transmission.

29.2.6. Parameter upload message

APC sends a parameter upload request, which contains indexes for max. five parameters. When the background communication task in the DCV has processed the message, it gives a response message. The parameter upload response is returned when the next **poll** arrives and there are no other higher priority messages waiting for transmission.

29.3. TC address selection

The APC board and the DCV 700 form a master-slave communication system where the APC board is the master and the DCV 700s are slaves. The master controls the use of the bus, and slaves can communicate only when the master is polling them. The master polls slaves one by one and slaves reply to the poll immediately.

The **polling** task in the APC board runs once every **2 ms**. The task polls only one DCV 700 at a time. So if there are four DCV 700s, one DCV 700 is polled once in every 8 ms.

Only those DCV 700 drives are polled that are defined in the application of the APC. The APC application has to contain at least a database block for the TC-link (DRLOO).

A unit number of the DCV700 is determined by jumpers of the **SDCS-COM_1** board as follows:

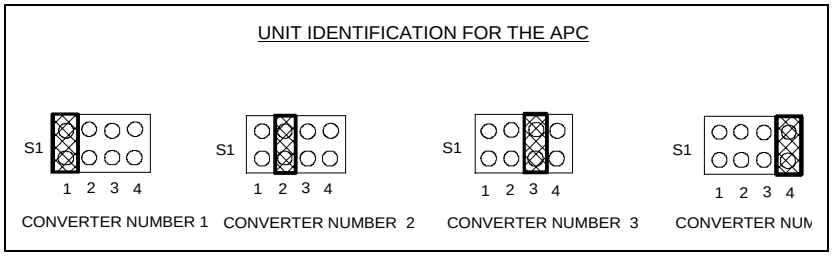


Figure 39 Determination of DCV700 unit's number in the TC-link.

The unit number can be read out from the parameter

STATION_ADDR (123-07).

29.4. DCV700 does not answer

If DCV 700 does not answer to two consecutive polls, APC commands the link to "closed" state and the polling task in the APC board enters into an operating state where it tries to restart the link. When DCV 700 responds to the poll again and a connection between APC and DCV 700 is opened, the APC application can start normal communication.

The TC-link status can be monitored from the signal

APC_LINK_STATUS (119-01):

0= link is operating
1= link is not operating
2= a time out has occurred
2= cold start

29.5. DCV700 does not receive any message

If DCV 700 does not receive any messages from APC for a defined time the link is declared as "closed". Action taken after that is defined by parameter:

APC_COM_BREAKRESP (19-.02):

0= stop with ramp. The DCV stops firing pulses when measured speed reaches the value defined by the parameter **ZERO_SPEED_LIMIT(12-09)**.
1= stop by the torque limit.
2= coast stop
3= no reaction
4= dynamic braking

The time-out is defined by parameter

APC_COMM_TIMEOUT (19-01)

When the APC board opens the link again, the DCV 700 will not clear any parameter settings or data link definitions without a command from the APC board.

29.6. APC watch-dog function

The purpose of the WATCH-DOG function is to confirm that the application program runs in a proper way in the APC. The serial communication tasks in APC are independent from the application program. This causes that the serial communication can run without problems although the application program is stopped. The WATCH-DOG function can detect this and stops the motor.

29.6.1. Principle of the watch-dog

APC changes the polarity of the bit 1 in **AUX_CONTROL_WORD (101-02)** faster than the time defined by parameter **WATCH-DOG TIME-OUT (19-03)**. DCV700 reads the bit and writes the value in to **AUX_STATUS_WORD (101-05)** bit 10. If the APC application program checks this bit, it can also supervise the drive control in DCV700.

If DCV700 does not detect a changing polarity during the defined time-out time, the drive will be stopped using a method defined by **WATCH-DOG BREAK_ ACK (19-04)** and to the fault-logger is written the text:

"**APC watch-dog error**" (-21-)

The state of the Watch-dog function can be seen from the signal **APC_WDOG_STATE (119-03)**. This signal is "-1" after watch-dog has tripped the drive and stays "-1" as long as the fault is reset.
This signal can be connected to some free DO-channel for external indication.

29.7. Special cases in APC - DCV700 communication

When DCV700 is in LOCAL-mode , the APC-time-out supervision does not trip the drive.

In LOCAL-mode, the time-out is 10 sec. This is for the reason that Windows-based DDCTool is able to write collected data to the disk. During the disk-writing Windows does not run the communication link.

In LOCAL-mode the Watch-dog function is disabled.

When the APC-communication is started, the state of the toggle-bit received from the APC is immediately written to the **AUX_STATUS_WORD (101-05)** but the watch-dog time-out function is not activated until 1 sec has elapsed.

The link close -command is handled as a normal time-out situation. The APC sends the close-command for example when a "BLOCK" command is given from "FCE"-editor.

29.8. APC function blocks for communication

The application controller board **APC has function blocks** called PC Elements and Drive Specific Blocks for communication to DCV 700 . The functional blocks are in a blocks library. The blocks have short names or symbols indicating the type of function they perform.

The functional blocks **DR_REC, DR_TRA, DRUPL**, **DRPAR** and **DRFLT** are used in communication between the APC board and the DCV 700.

The **DR_REC (C1, C2)** (DRive RECeive) block is used to receive messages from the DCV 700. An address determines from which drive the message is read. Basic or cyclic message is selected with a call parameter C1. The number of received data is determined with a call parameter C2. All received values are integers.

Call parameters

Parameter	Significance	Permissible values
C1	Type of receiving block	0 = to read basic message 1 = to read cyclic message
C2	Number of received data	3 if C1 = 0 1..8 if C1 = 1

The **DR_TRA (C1, C2)** (DRive TRAnsmit) block is used to transmit messages to DCV 700. There are two kinds of messages: broadcasting and addressed messages. Broadcasting messages are received by all drives. In addressed messages a drive number determines to which drive the message is sent. An addressed message can be a basic or cyclic type of message.

Basic, cyclic or broadcasting transmission mode is selected with a call parameter C1. The number of transmitted data is determined with a call parameter C2. The block transmits integer values.

Call parameters

Parameter	Significance	Permissible values
C1	Selection of transmission mode	0 = basic message 1 = cyclic message 2 = broadcasting message
C2	Number of transmitted data	3 if C1 = 0 1..8 if C1 = 1 1..5 if C1 = 2

The **DRUPL (C1)** (DRive parameter UPLoad) block is used to upload parameters from the DCV 700. An address determines from which drive the message is received. The number of received parameters are determined with a call parameter C1. All received values are integers.

Call parameters

Parameter	Significance	Permissible values
C1	Number of received parameters	1...5

The **DRPAR (C1)** (DRive PARameter download) block is used to download parameters to the DCV 700. A drive number determines to which drive the parameters are sent. The number of transmitted parameters is determined with a call parameter C1. The block transmits integer values of parameters.

Call parameters

Parameter	Significance	Permissible values
C1	Number of transmitted parameters	1...5

The **DRFLT** (DRive FauLT) element is used to read fault information (number and time) from the DVC 700 and write the appropriate Drive Fault Event to the selected Event Logger buffer.

29.9. DDCTool link

The DDCTool-link runs at 1,5 Mbits/s using the HDLC protocol. The link needs an external board **SNAT 606/608 CMT** in PC. The DDCTool-program is installed in a PC.

Normally this is enough to control the drive, but if several drives are to be controlled by one PC, optical distributor **YPC 111 A** must be used.

The YPC 111 A has one connection for SNAT 606 CMT and four connections for DCV 700s or lower level optical distributors. Optical distributors can be connected to a tree or chain form. The height of the tree/length of the chain depends on the number of DCV700s in the system. It is possible to connect up to 249 DCV 700s to one PC.

Node addresses for DCV 700s for the link is made by parameter

DDC_TOOL_ADDRESS (23-02)

1... 249, address 250 is used in the single drive application.

29.10. Master/Follower -link

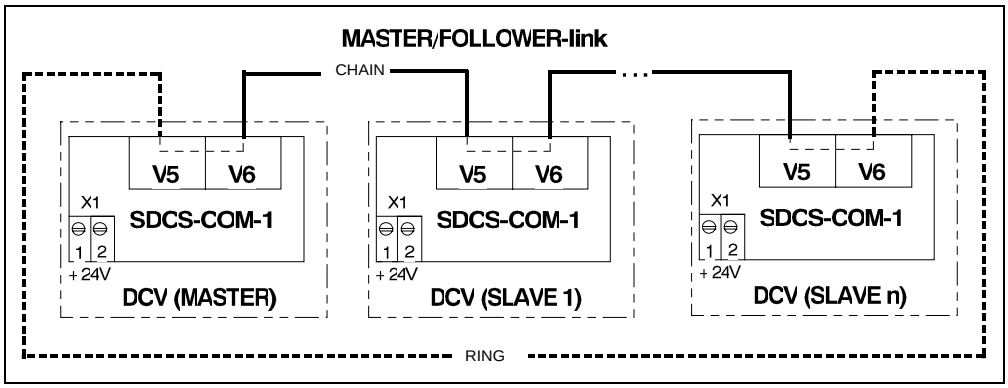


Figure 40 Principle of the Master/Follower-link connections.

The Master/Follower-link runs at 25 kbits/s using the plastic fibre cables. The transmission interval from the master to the slave(s) is **3.3 ms.**

For example, the torque reference of master can be transmitted directly to the slave(s). This solution is more efficient than the solution where the APC takes care of all transmissions of torque reference to each slave.

The physical connection of master/follower link is as follows: Connectors for the fibre optic link are on **SDCS-COM-1 board.** In addition, the master/follower link needs only the plastic fibre cables. The master transmits the torque reference from **V6** into **V5** in the slave. If there are more than one slave, the reference of master is **continued directly** from **V6** of first slave to the next slave's **V5**, and so on.

It is possible to connect an unlimited number of slaves together and finally a **chain** or a **ring** is formed. In the ring it is possible to change master(s) in the ring by the APC resetting the Master/Follower parameters. Each master in the ring will break it. The changing master transmits a new reference value to slave(s) which locate in the ring after that master.

An external power supply can be connected to the SDCS-COM-1 board for the Master/Follower-link via terminal **X1**. Thus, a cut off intermediate voltage of the unit does not cause a break in the link. Selection between external and internal voltage supply are made by jumper **S2**

Parameters to be set in **master** drive:

MASTER_FOLLOWER_MODE (20-01)
1 = Drive is selected to master.

MASTER_SIGNAL (20 02)
xx-yy = source of the reference value.

Parameters to be set in the **slave** drive(s):

MASTER_FOLLOWER_MODE (20-01)
1 = Drive is selected to slave.

FOLLOWER_SIGNAL(20-03)
= destination of reference value.

FOLLOWER_TIMEOUT(20-04)
= time elapsed from the last received value.

In case of time-out the slave updates **AUX_STATUS_WORD(101-05.7).**
The drive does not react to the time-out, the supervision must be done in the APC application program.

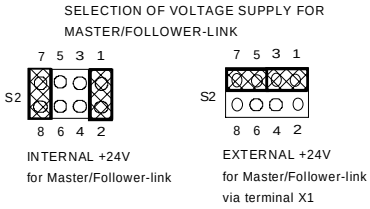


Figure 41 Strap settings of voltage source.

29.11. Field excitation communication

Between control board and field exciters SDCS-FEX-1/DCF503/4 are RS 485 serial communication link with speed of 62.5 kbits. The update interval of the field current reference is 10 ms. To the link it is possible to connect up to two field exciters so that the second unit is always DCF503/4. Address coding for the link is made by means hardware jumper in the second unit.
The unit reads the address only when power are connected.

The parameters of field exciters are downloaded every time when power are connected to the converter or during normal operation every time when some parameter changes are done.

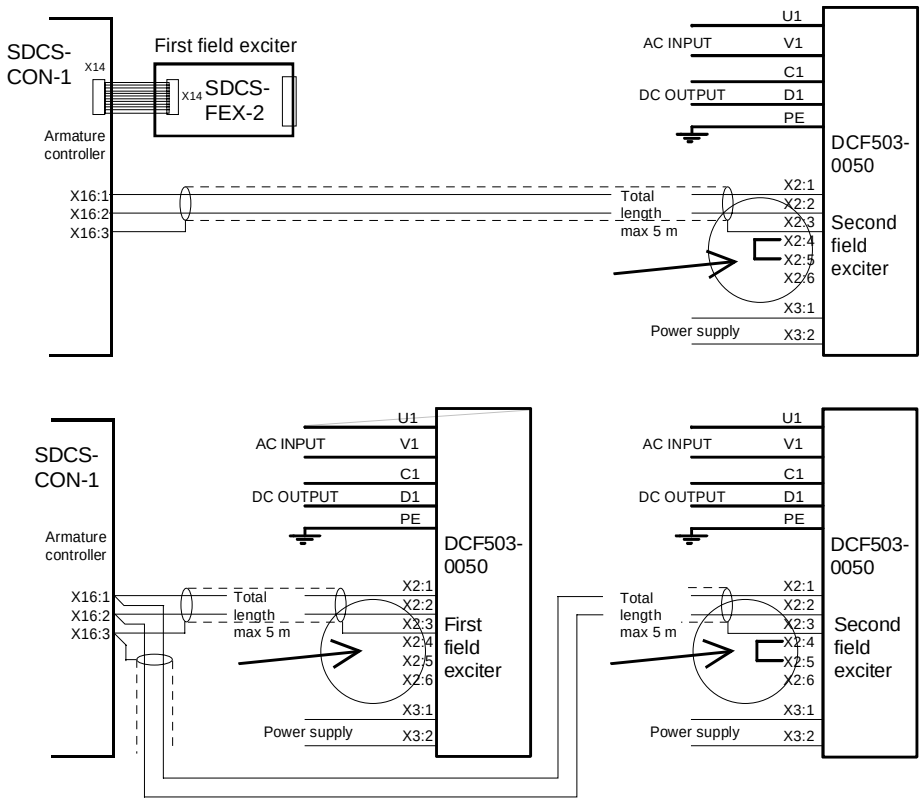


Figure 42 Serial communication cable connection and address setting.

In the program the selection between field exciters is made by means of the parameter:

FEXC_SEL (11-10):

0= No field exciter
1= Internal diode field exciter SDCS-FEX-1
2= Internal SDCS-FEX-2 or external DCF503/504 as a first field exciter
3= ext DCF503/504 as a second field exciter
4= Int SDCS-FEX-2 or ext DCF503/504 as a first field exciter and ext DCF503/504 as a second field exciter
5...13 External field exciters

Both field exciters have own individual status signals for the communication:

FEXC1_COM_STATUS (123-12) first field exciter
FEXC2_COM_STATUS (123-13) second field exciter

0= OK
B0 time-out when write parameter, no echo for address
B1 time-out when write parameter, no values received
B2 time-out when read parameters, no echo for address
B3 time-out when read parameters, no values received

B4 time-out when read actual values, no values received

Communication errors can be read out from the signals:

FEXC1_COM_ERRORS (123-14) first field exciter
FEXC2_COM_ERRORS (123-15) second field exciter

30. REVISION HISTORY

A brief description of the differences in program versions and the versions of the manuals related to revisions.

FPROM memory circuits are located in the control board SDCS-CON (identification labels of circuits are in the board D33 and D34)

30.1. Version DC11.102

Documents: Software Description 1.0
Revision A
3AFE 61101446

30.2. Version B

Documents: Software Description
Revision B

Some part of the document re-organised
Next functions added:

- D-part for speed controller
- Position counter
- Auto-reclosing function
- Gear backlash function
- APC watch-dog function
- Static fault and alarm codes

ABB Industrietechnik AG
Produktbereich Antriebstechnik
Postfach 1180
D-68619 Lampertheim
Telefon (0 62 06) 5 03-0
Telefax (0 62 06) 5 03-5 63
Telex 4 62 411605 ab d